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DELAWARE VALLEY WORKS FACILITY SOUTH PARCEL, PHASE 2 PRE-DESIGN INVESTIGATION REPORT

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1. INTRODUCTION

1.1 Overview and Purpose

On behalf of Drawbridge Claymont, LLC (Drawbridge), Geosyntec Consultants (Geosyntec) has prepared this Pre-Design Investigation (PDI) Report for the Delaware Valley Works (DVW) South Parcel, Phase 2 (the Site) (RCRA ID No. DED154576698) located in Claymont, Delaware. The Phase 2 property is the subject of an Administrative Order on Consent (AOC) RCRA-03-2016-0232CA issued by the United States Environmental Protection Agency (USEPA) under the Resource Conservation and Recovery Act (RCRA).

This PDI Report presents the geotechnical information collected during the implementation of the approved PDI Workplan (Geosyntec, 2020) and a recommended approach to prepare a revised 30% design for a capping system for the Site. This PDI Report is prepared for submittal to the USEPA and Delaware Department of Natural Resources and Environmental Control (DNREC).

The final remedy for the South Parcel consists of institutional and engineering controls. The engineering controls include installing a low permeability cap that shall be designed and constructed to prevent infiltration to mitigate potential cross-media migration (soil to groundwater) of contaminants. The cap will also prevent direct contact with contaminants in the subsurface and limit the overland transport of contaminants to the adjacent Delaware River. The remediation of the Phase 1 area in the South Parcel was completed in 2019. This area was redeveloped as a railyard and the underlying cap consisted of either 60-mil or 40-mil LLDPE geomembrane overlain by a geocomposite drainage layer and a minimum of 16-inches of cover soil above which the geotextile and railyard ballast. This cap design and construction was aligned with the specific end use of the Phase 1 area. Similarly, the cap design and construction for the Phase 2 area will be aligned with the anticipated future use of Phase 2, which is anticipated to be pier access, truck parking, warehouse facilities, or bulk storage.

This PDI Report is supported by several other work plans and investigations conducted at the Site. A geotechnical investigation was conducted in 2017 in the northern portion of the South Parcel as part of Phase 1 capping and development which saw the construction of a railyard for Conrail [AECOM, 2017]. The PDI workplan for Phase 2 capping was approved in February 2020 [Geosyntec, 2020] and is the basis for this PDI report.

The following report summarizes the PDI and presents data and recommendations to prepare a remedial design for the Site that is consistent with the remedial objectives.

1.2 PDI Report Objectives

The three primary objectives of the PDI Report are as follows:

(1) Present supplemental data collected at the Site and an evaluation of the subsurface conditions, in particular subsurface permeability, to design a cap that is equal to or less permeable than the underlying materials;

(2) Present geotechnical information that can be used for future Site redevelopment; and

(3) Recommend an approach for the 30% design of a final remedy that meets the functional capping requirements of 40 CFR Section 265 (Landfills) Subsection 310 (Closure and Post-Closure Care) and is consistent with the anticipated future Site use.

1.3 Remedy Description

The selected remedy for the 22-acre Site (the South Parcel) is a combination of engineering and institutional controls outlined in the Statement of Basis [USEPA, 2016a] and the Final Decision and Response to Comments [USEPA, 2016b] and addresses the following corrective action objectives (CAOs) for soil and groundwater:

> Soil: "*Prevent all uncontrolled human exposure to contaminated soils that exceed the industrial RSLs and minimize cross-media transfer of contaminants of concern (COCs) from soil to groundwater and surface water to minimize the impact to ecological receptors*." [USEPA, 2016a]

> Groundwater: "*While this SB does not include a proposed remedy for groundwater and because contaminants remain in the groundwater at the South Parcel, EPA is including a proposed corrective action objective for groundwater to prevent any other unacceptable exposures to impacted groundwater and ensure that groundwater containing elevated concentrations of COCs will not impact ecological receptors nor adjacent surface water bodies*." [USEPA, 2016a]

Groundwater is only being considered here as it relates to future controls to protect against unacceptable cross-media migration inasmuch as Honeywell International Inc. (Honeywell) is legally responsible for groundwater at the South Plant.

As detailed in the USEPA Statement of Basis [USEPA, 2016a] and Final Decision and Response to Comments [USEPA, 2016b] the selected remedy for the South Parcel is as follows:

> *The proposed remedy for the South Parcel soils is to install and maintain a low permeability cap that controls, minimizes, or eliminates, to the extent necessary to protect human health and the environment, post remedial action escape of hazardous waste, hazardous constituents, leachate, contaminated run-off, or hazardous waste decomposition products to the ground or surface waters or to the atmosphere. In addition, the cap shall be designed and constructed to prevent infiltration to mitigate potential cross-media migration (soil to groundwater) of COCs. This cap shall be functionally equivalent to the performance standards documented in 40 CFR Section 265.310."* [USEPA, 2016a].

The South Parcel phase I capping was constructed in 2017. The phase II capping will integrate with the adjacent capping system constructed beneath the railyard, as well as future corrective action for the sluiceway and shoreline sediment.

1.4 PDI Report Organization

The remainder of this PDI WP is organized as follows:

- Section 2 presents the physical description of the Site including a summary of the Site and its Site characterization;
- Section 3 presents the pre-design investigation activities and collected data;
- Section 4 presents an interpretation of the data collected and along with site subsurface information including geology, subsurface, and geotechnical findings; and
- Section 5 presents the approach for the 30% design.

2. SITE DESCRIPTION

2.1 Introduction

A description of the Site including the Site setting and land use, Site history, and previous Site characterization activities is presented in this section. The information presented herein was previously detailed in the *RFI Summary and Presumptive Remedy for Proposed Industrial Redevelopment Area* [Woodard & Curran, 2016], *Corrective Measures Implementation 100% Design Report Phase 1 of Remedy* [AECOM, 2017], and the *RCRA Corrective Measures Implementation 30% Design Report Phase 2* [Environmental Alliance, Inc., 2019].

2.2 Site Setting and Land Use

The DVW South Parcel Site is located along the Delaware – Pennsylvania border in an industrial area of New Castle County, Delaware, situated between Philadelphia Pike (Route 13) and the north shore of the Delaware River, approximately 0.2 miles west of the Pennsylvania State line. The Site and adjacent areas have been used for industrial purposes for more than 100 years. The Site location is shown on **Figure 1**.

A review of historical topographic maps from the United States Geologic Survey (USGS) from 1896 to 2016 was also conducted. The Site was undeveloped in late 1800s and early 1900s. By 1941 the Site and adjacent properties were industrialized with several buildings and rail lines on Site. Historic photos show bulk storage tanks are visible at the adjacent property to the west, as are the piers that border the Delaware River to the south both on-Site and to the west. Bulk storage tank is currently present adjacent to the west property boundary. A wet area has been constructed on the property to the east in the 1970s which appears to have been infilled and identified as a disposal site by 1993 and is mounded. The mound is visible in the 2016 topographic map. The 2011 to 2016 topographic maps illustrate a near-shore area that appears to be infilled sediments.

The historical site comprised a chemical manufacturing facility straddling the Philadelphia Pike (Route 13). The North Plant facility is currently owned and operated by Honeywell. The South Plant is an inactive (demolished) chemical manufacturing facility formerly operated by General Chemical which was acquired by Chemtrade Solutions LLC (Chemtrade) in 2014. The DVW South Plant site is the subject of an Initial Administrative Order issued to General Chemical LLC which formerly operated the South Plant [AECOM, 2017a].

The South Plant was subdivided in 2016 into a North Parcel and South Parcel. The South Parcel is 22 acres in size plus 5 acres of nearshore riparian zone. The South Parcel was further divided into two remedial and development units – Phase 1 is approximately 13 acres and has already been capped and developed as a railcar storage yard, and Phase 2, approximately 9 acres, is the focus of this PDI (Site). Drawbridge purchased the South Parcel of the South Plant in August 2016 [U.S. EPA, 2017b). The Phase 2 parcel is bordered to the east by a sluiceway which conveys stormwater runoff from the North Parcel and North Plant. The sluiceway and the sediments in the riparian zone are to be addressed separately by Honeywell and Chemtrade. Currently all buildings have been demolished, however, some concrete slabs are present and other subsurface structures may also be present at the Site. A Site plan is shown in **Figure 2.**

2.3 Previous Site Characterization

The IAO issued for the DVW South Plant was dated 2000 following a RCRA Facility Assessment in 1986. Since then, a number of investigations and reports related to the DVW South Plant have been prepared. They include, but are not limited to, the following:

- RFI Work Plan (2002)
- RFI Phase II Work Plan (2005)
- RFI Phase II Report (2007)
- USEPA Sediment Sampling (2008)
- Revised Work Plan (2010)
- Sediment, Soil, and Groundwater Data Submittal (2010)
- Interim Remedial Measure Alternatives Assessment, Upper Portion of Sluiceway (2012)
- Interim Remedial Measure Alternatives Assessment Closure Report (2013)
- RFI Summary and Presumptive Remedy for Proposed Industrial Redevelopment Area Final (Woodard & Curran, 2015 Final]
- Statement of Basis [USEPA, 2016]
- Final Decision [USEPA, 2016]
- RFI Summary and Presumptive Remedy for Proposed Industrial Redevelopment Area Final [Woodard & Curran, 2016 Revision 2]
- Corrective Measures Implementation Work Plan [AECOM, 2017]
- Geotechnical Report for Corrective Measures Implementation [AECOM, 2017]
- Corrective Measures Implementation (CMI) 100% Design Report for Phase 1 of the Remedy [AECOM, 2017]
- Corrective Measures Implementation 30% Cap Design Report for Phase 2 of the Remedy [Environmental Alliance, Inc., 2019]

Collectively, these investigations and reports indicate that the Site has been extensively investigated and characterized for environmental conditions and describe the area that is the subject of the Statement of Basis [USEPA, 2016].

Overall, the South Parcel of the DVW Site contains ten solid waste management units (SWMU) and four Areas of Concern (AOC), of which the following six SWMU and two AOC are within the Phase 2 portion (the Site):

- SWMU 1 Former North Phosphoric Acid Pond;
- SWMU 2 South Phosphoric Acid Pond;
- SWMU 7 Effluent Clarifier;
- SWMU 26 South Waste Treatment Plant;
- SWMU 35 Former Hazardous Waste Storage Pad;
- AOC 2 Acid Spill Area; and
- AOC 14 Former Sulfuric Acid Storage Tank Area Sump.

Contaminants of potential concern (COPC) in soil at the Site include metals, notably arsenic and lead, and the polycyclic aromatic hydrocarbon benzo[a]pyrene at depths ranging from approximately 0 to 7 feet below ground surface (bgs). Historical results also indicate that there are metals in groundwater, and pesticides in soil and groundwater [Woodard & Curran, 2016].

3. PRE-DESIGN INVESTIGATION ACTIVITIES

3.1 Investigation Approach

In February 2020, Geosyntec conducted the PDI in accordance with the USEPA-approved PDI Work Plan [Geosyntec, 2020]. Nine (9) soil sampling borings (B-16-20 to B-24-20) were advanced using a hollow-stem auger (HSA) by Summit Drilling Co., Inc. (Summit) of Bridgewater, New Jersey under Geosyntec's supervision. The borings were installed to evaluate subsurface geotechnical conditions in the South Parcel Phase 2 Area using standard penetration tests (SPTs) and Shelby tube samples to estimate subsurface permeability and geotechnical properties. The approximate borehole locations are shown on **Figure 2**.

3.2 Borehole Installation and Soil Sampling

Prior to drilling, Summit obtained the necessary drilling permits from DNREC. The locations of buried utilities were identified prior to all drilling activities. Miss Utility of Delmarva was contacted to locate underground public utilities to the property boundary. In addition, a private locator (Subsurface Environmental Technologies) was subcontracted to conduct a geophysical survey on approximate 20-foot by 20-foot areas surrounding the proposed drilling locations to confirm that they were clear of buried utilities.

The boreholes were advanced using HSA and soil samples were collected throughout the overburden material using split spoon. Split spoons were advanced in 2-foot intervals with a 140-pound automatic hammer and a 30-inch drop height. Blow counts were recorded for each foot advanced in order to gauge the relative density and consistency of subsurface materials and for correlations to shear strength. Split spoons were collected continuously for the first 10 feet bgs at each borehole, and every 5 feet below 10 feet bgs. Geosyntec personnel logged lithologic characteristics and screened each spoon with a photoionization detector (PID) and pocket penetrometer used on fine-grained samples at 6-inch intervals. Following field logging and screening, bulk soil samples from each spoon were placed in a sealed plastic bag for transportation to Hillis-Carnes Engineering Associates (HCEA), the geotechnical laboratory.

A subset of the depth intervals was selected for Shelby tube sample collection based upon lithologic characteristics as determined by Geosyntec personnel. Sample intervals were selected to represent fine-grained soils of Strata 2 and 3 (all strata are described in Section 4). Additionally, one sample was collected from Stratum 4 at boring B-16-20. Summit collected each Shelby tube and sealed each end with wax. Shelby tube samples were stored and transported to HCEA by Geosyntec in a secure manner to reduce the potential for soil disturbance.

Five of the borings (B-17-20, B-18-20, B-19-20, B-21-20, and B-24-20) were terminated at the base of Stratum 2, at depths between 20 and 37 feet bgs, for capping design purposes. Boring B-16-20 was advanced to 27 feet bgs, in Stratum 4, and two borings were advanced to the base of Stratum 4 (B-20-20 and B-22-20; at 52 and 32 feet. bgs, respectively). Deeper borings were installed for future geotechnical purposes. Boring B-23-20 was terminated at 1.2 feet bgs due to refusal.

Following sampling, each borehole was backfilled with Portland cement-bentonite grout mix by tremie grouting. Drill cuttings were added to an existing stockpile on-Site ("Spoils Stockpile from Phase 1", adjacent to boring B-21-20), as specified in the USEPA-approved PDI Work Plan. Water generated from drilling and decontamination fluids was inspected for non-aqueous phase liquid (NAPL) or sheen. When no NAPL or sheen was observed, water was discharged to the ground surface near the location from which it was generated, at a rate allowing for infiltration and return to the surficial aquifer system. Materials containing NAPL or sheen were containerized in a 55-gallon steel drum and placed by the spoils stockpile for off-Site disposal.

All split spoon and Shelby tube samples were submitted to HCEA for geotechnical analysis as specified by Geosyntec. A summary of the analyses completed is included in **Table 1**.

3.3 Equipment Cleaning

Equipment that was reused and that came into contact with potential contaminated material during the field investigation was decontaminated before use, between borehole locations, and after use.

Large equipment including drill rigs, support vehicles, drilling rods, and augers that came in contact with potential downhole contamination, both as part of subsurface equipment advancement and above-ground contact with drilling fluids, extracted soils, or ground water were decontaminated prior to and after use. Decontamination of large equipment was performed by a pressure wash and Alconox to clean the inside and outside of drilling equipment. Dry decontamination, which includes physical removal of solids by brushing, was performed on large equipment tires and tracks to remove potentially contaminated solids that originate from surfaces that do not have an approved cover system. Liquid and solid material produced from this operation were managed as described in Section 3.2.

Small soil sampling equipment that includes soil sampling devices (split spoons) were decontaminated by removing adhered soil, washing with a non-phosphate soap and water (e.g., Alconox), scrubbing until visibly clean and rinsing with potable water to remove the soap solution.

4. SITE CHARACTERIZATION

4.1 Topography

The Site is relatively flat and surface runoff is presumed to drain south to the Delaware River. The general surface topography appears relatively constant since the 1970s. As discussed above, the sluiceway which runs along the east side of the South Parcel acts as a stormwater drainage path for portions of the South and North Plants.

4.2 Geology

A review of Delaware geologic units present in the region of the DVW facility indicates that the Site is underlain by fine-grained Holocene alluvial deposits above Trenton Gravel. The Trenton Gravel generally consists of gravelly sand with interbedded sand and clay-silt layers [AECOM, 2017a]. Bedrock at the Site consists of Wilmington Complex Ardentown Granitic Suite from the Silurian age [Schenk et al, 2000]

4.3 Subsurface

4.3.1 Soil

In 2015 and 2016, in support of the Phase 1 capping and development, fifteen test soil borings (identified as B-x in **Figure 2**) were drilled to maximum depths of approximately 42 to 62 feet bgs and 21 test pits (identified as TP-x in **Figure 2**) were excavated to depths of approximately 5 feet bgs or refusal [AECOM, 2016]. The test pits were installed up to 5 feet bgs. Logs indicate that subsurface conditions encountered are fill and sand materials, and some metal, wood, brick, and concrete debris. Borings were installed across the South Parcel Phase 1 and a portion of the Phase 2 Site. Historic borings installed at the Site (Phase 2) are B-04, B-08, B-09, and B-11. A summary of all the borings installed at the South Parcel is presented in **Table 2**.

In 2015, as part of the RFI Phase II investigation [Woodard & Curran, 2016], 43 soil samples from 16 locations were collected using a Geoprobe to 10 feet bgs to determine source and extent of COPC (identified as SSI-X in **Figure 2**). The boring logs from this investigation describe the subsurface as approximately 2 to 5 feet of fill, sand, and rock fragments underlain by wet clay materials.

The water table is described as being between 4 and 10 feet bgs (2016) and between 9 to 12 feet bgs (2006). A groundwater sampling investigation conducted as part of the RFI Phase 2 in 2006 found that it was difficult to collect a groundwater sample from the shallow groundwater bearing zone due to the low permeability of the fine-grained subsurface soils. A grain-size analysis from the saturated zone (depth 10 to 12 feet bgs) is reported to have a high proportion of fine-grained materials with 56.7 percent silt, 2.6 percent clay, and 14.9 percent fine sand [Woodard & Curran, 2016].

In February 2020, Geosyntec conducted a PDI that involved the advancement of nine borings that range in depth from 1.5 to 52 feet bgs. SPT values were recorded and split spoon and Shelby tube samples were collected for geotechnical laboratory testing. Borehole logs are included in **Appendix A**.

The subsurface is described as having six strata in descending order as follows:

- Stratum 1 (Fill) – brown, loose to very dense silty sand and gravel (upper), stiff sandy silty clay (lower), with brick, concrete, and wood.
- Stratum 2 – dark gray, soft to medium stiff silty clay and clayey silt, with organic materials.
- Stratum 3 – brown, stiff to very stiff sandy silty clay and clayey silt.
- Stratum 4 – brown and gray, medium dense to very dense silty sand and gravel.
- Stratum 5 (Residual Soil) – gray and light gray, dense to very dense silty sand, very stiff to hard sandy silt and silty clay, with relict rock structure.
- Stratum 6 (Decomposed Rock) – light gray and dark gray, very dense silty sand, hard sandy silty clay and clayey silt, with relict rock structure.

Four cross-sections of the Site are presented in **Figures 3, 4, 5, and 6**. In general, the Stratum 1 fill increases in thickness from 4 to 20 feet thick towards the Delaware River. Stratum 2, soft clayey silt containing organics, extends below the fill material to a thickness of 28 feet, and deeper than 37 feet where Stratum 3 is not present. Borings B-17-20, B-18-20, and B-24-20 were terminated in Stratum 2 at 37 feet bgs. Stratum 3 is discontinuous – it is present in the northwest portion of the Site but is largely absent from the remainder of the portion of the Site investigated in 2020. Boring B-20-20 was installed to a depth of 52 feet bgs extending into the coarse Stratum 4.

4.3.2 Groundwater

In borings advanced in 2020, groundwater was encountered at depths ranging from a 5 to 15 feet bgs corresponding to elevations of approximately +8 to -3.5 ft above mean sea level. Groundwater depths and elevations are presented in **Table 2**. Honeywell is responsible for addressing groundwater.

4.4 Geotechnical

A geotechnical investigation was carried out by AECOM in 2017 to formulate recommendations for the foundation construction and earthwork for the Phase 1 capping. Fifteen borings were advanced under AECOM supervision using a truck-mounted CME-55 drilling rig: eight using HSA drilling techniques (B-1 through B-8) and seven using mud rotary drilling techniques (B-9 through B-15). Samples were obtained using split-barrel samplers (via SPTs) and thin-walled tube samplers (i.e., Shelby tubes). Penetration resistance was recorded during SPTs to gauge the relative density of subsurface materials and a pocket penetrometer was used on fine-grained samples to estimate soil consistency and unconfined compressive strength.

A geotechnical investigation was carried out by Geosyntec in 2020 to formulate recommendations for the Phase 2 capping design. Nine borings (B-16-20 to B-24-20) were advanced under Geosyntec supervision using a truck-mounted Diedrich D120 HSA. Samples were obtained using split-barrel samplers (via SPTs) and thin-walled tube samplers (i.e., Shelby tubes). Penetration resistance was recorded during SPTs to gauge the relative density of subsurface materials and a pocket penetrometer was used on fine-grained samples to estimate soil consistency and unconfined compressive strength. The SPT values are shown on the boring logs (**Appendix A**) and in the site cross sections (**Figures 3 to 6**).

Laboratory testing was performed to characterize and determine index properties of soil samples, and included: moisture content, Atterberg limits, grain size distribution, and organic content. Falling head permeability tests were performed to determine hydraulic conductivities of soils. One-dimensional incremental loading consolidation tests were performed to determine compressibility properties of soils. Unconsolidated-undrained (UU) and consolidated-undrained (CU) triaxial compression tests were performed to assess the shear strength properties of soils. Laboratory reports are included in **Appendix B**. A calculation package (**Appendix C**) was carried out to develop recommended geotechnical soil properties for designing the low permeability cap and for future site redevelopment.

Laboratory testing results from the previous investigation performed by AECOM [2017a] and results from the investigation performed by Geosyntec in February 2020 were both considered in evaluating the geotechnical characteristics of fill and soil in Phase 2, and in developing recommendations for capping to fulfill the CAOs for the Site.

4.4.1 Permeability

Hydraulic conductivity analysis was conducted for the coarse-grained strata (1 and 4) and obtained from laboratory testing for the fine-grained strata (2 and 3). Their respective results are discussed below.

<u>Hydraulic Conductivity of Coarse-Grained Strata</u>

Hydraulic conductivities of coarse-grained strata were not directly measured due to the difficulty in obtaining an undisturbed sample, and in-situ slug or infiltration testing is impractical due to the shallow nature of Stratum 1. Instead, hydraulic conductivities were estimated from sieve analysis results using the Kozeny-Carman formula as presented in Carrier [2003]. This semi-empirical, semi-theoretical formula for predicting the permeability of porous materials is based on the entire particle size distribution of the soil, the particle shape, and the void ratio (**Appendix C**).

Samples from Stratum 1 generally classified as silty sand and gravel fill. Estimated vertical hydraulic conductivities ranged from 1.6×10^{-6} centimeters per second (cm/s) to 2.9×10^{-4} cm/s with a geometric mean of 2.2×10^{-5} cm/s. These values fall within the range of values presented in Terzaghi and Peck [1967] for typical mixtures of sand, silt, and clay (1.0×10^{-7} cm/s to 1.0×10^{-3} cm/s). One sample obtained from Stratum 1 at boring B-15 classified as sandy lean clay and was not considered in the estimate. The Kozeny-Carman formula assumes there are no electrochemical reactions between soil particles and pore water. Therefore, the formula is applicable for coarse materials and nonplastic silts but not for clayey soils.

Samples from Stratum 4 generally classified as silty sand and gravel. Estimated vertical hydraulic conductivities ranged from 1.8×10^{-6} cm/s to 3.2×10^{-4} cm/s with a geometric mean of 2.2×10^{-5} cm/s. These values fall within the range of values presented in Terzaghi and Peck [1967] for typical mixtures of sand, silt, and clay (1.0×10^{-7} cm/s to 1.0×10^{-3} cm/s).

<u>Hydraulic Conductivity of Fine-Grained Strata</u>

Hydraulic conductivities of samples obtained from fine-grained strata (i.e., Stratum 2 and Stratum 3) were measured from flexible-wall triaxial permeability tests. Test specimens were generally consolidated to the mean effective stress they were originally subjected to in the field in order to evaluate the hydraulic conductivity of soils within the stress range of interest for the Site. Falling head hydraulic conditions were used for permeability tests.

Samples from Stratum 2 generally classified as silty clay and clayey silt with organics. Vertical hydraulic conductivity results from permeability tests performed on samples from Stratum 2 ranged from 1.2×10^{-7} cm/s to 3.6×10^{-6} cm/s with a geometric mean of 4.7×10^{-7} cm/s. These values are similar to the lower bound of the range of values presented in Terzaghi and Peck [1967] for typical mixtures of sand, silt, and clay (1.0×10^{-7} cm/s to 1.0×10^{-3} cm/s).

One-dimensional incremental loading consolidation tests were also performed on samples obtained from Stratum 2. For consolidation tests where time-deformation measurements were recorded for each load increment, hydraulic conductivities were back-calculated based on the rate of consolidation. Vertical hydraulic conductivity results from consolidation tests performed on samples from Stratum 2 ranged from 3.2×10^{-8} cm/s to 1.3×10^{-7} cm/s with a geometric mean of 7.3×10^{-8} cm/s. These back-calculated values are less permeable than, but comparable to hydraulic conductivities obtained from permeability tests.

Samples from Stratum 3 generally classified as sandy silty clay and clayey silt. Vertical hydraulic conductivity results from one permeability test performed on a sample from Stratum 3 had a result of 4.2×10^{-7} cm/s. This value is similar to the lower bound of the range of values presented in Terzaghi and Peck [1967] for typical mixtures of sand, silt, and clay (1.0×10^{-7} cm/s to 1.0×10^{-3} cm/s).

<u>Soil Anisotropy</u>

Soil deposits are generally anisotropic with horizontal stratification due to horizontal bedding in natural deposits or construction in horizontal lifts for fill materials, usually resulting in horizontal hydraulic conductivity being greater than vertical hydraulic conductivity. Anisotropy is defined by the ratio of horizontal hydraulic conductivity (k_h) to vertical hydraulic conductivity (k_v). Laboratory testing usually measures the value of vertical hydraulic conductivity consistent with the orientation of borehole samples.

Natural soils deposited by water such as fluvial deposits are typically stratified and may have anisotropy ratios greater than 100 [USBR, 2014]. For example, coarse-grained strata may exist within the fine-grained strata at the Site which could significantly increase horizontal hydraulic conductivity. While vertical hydraulic conductivity will be controlled by the fine-grained materials, horizontal hydraulic conductivity will be controlled by the coarse-grained interlayers. If anisotropy ratios are needed to model seepage at the Site for future development, a parametric study in which anisotropy ratios of 1, 10, 25, and 100 are considered [USACE, 1986] can be performed. No anisotropy ratio is recommended at this time due to lack of field testing data to characterize horizontal hydraulic conductivity of soils (e.g., slug tests, pore pressure dissipation tests).

Coarse-grained deposits such as the surficial fill layer and the deeper silty sand layers are usually assigned an anisotropy ratio of 1.0 but can usually range from 1.0 to 3.0 [USBR, 2014]. It may be expected that the deeper natural coarse-grained deposits may have anisotropy ratios at the higher end of this ratio while the surficial fill layer was likely placed in thicker lifts without much compactive effort, resulting in a lower anisotropy ratio.

4.4.2 Settlement

Results of the geotechnical investigation described by AECOM [2017a] were used to estimate primary and secondary settlements due to placement of new fill and live loads (i.e., railcars). Settlement is primarily attributed to the highly compressible Stratum 2 (soft, organic fine-grained soils up to 28 ft in thickness in Phase 1 parcel). Primary settlement from new fill placement was estimated to generally range from 0.5 to 2.5 inches across the Site, with up to 6 inches. near the north end of the Site. Primary settlement due to storage of railcars was estimated to be on the order of 1.5 inches in addition to settlement due to new fill. Secondary (i.e., creep) settlement was estimated to range from 1 to 3 inches over a 20-year period.

Depending on the loading and infrastructure selected for redevelopment, the presence of existing foundations may be a potential source for differential settlements, since areas with existing foundations could experience little settlement while adjacent areas with no existing foundations could experience the full magnitude of settlement from new fill and live loads.

Compressibility parameters were developed by Geosyntec based on the previous AECOM investigation [2017a] and the recent investigation by Geosyntec, as described in **Appendix C.** The results were similar to those used by AECOM previously. Note that specific settlement estimation was not performed since the redevelopment loads have not been identified.

4.4.3 Additional Material Properties

Specific future development at the Site beyond construction of the low permeability cap is unknown but is likely to include a combination of truck parking, warehouse, bulk storage, and pier access. Additional geotechnical data were collected in the PDI phase to assist with future Site development and to minimize the need for future geotechnical investigation borings (penetrations to the Site cap). The following geotechnical properties were developed as described in **Appendix C**:

- Density properties
- Hydraulic conductivities
- Compressibility and elastic moduli
- Normalized SPT resistance values
- Drained and undrained shear strength parameters

These geotechnical properties may be useful for future analyses such as: (i) bearing capacity and settlement analyses of shallow foundations; (ii) axial and lateral resistance of driven piles and drilled shafts; (iii) lateral earth pressures for buried structures and retaining walls; and (iv) seismic design parameters and liquefaction evaluations.

5. RECOMMENDATIONS FOR CAP DESIGN

5.1 Remedial Objective

As noted in Section 1.3, the objective for the selected remedy for the South Parcel is as follows:

> *The proposed remedy for the South Parcel soils is to install and maintain a low permeability cap that controls, minimizes, or eliminates, to the extent necessary to protect human health and the environment, post remedial action escape of hazardous waste, hazardous constituents, leachate, contaminated run-off, or hazardous waste decomposition products to the ground or surface waters or to the atmosphere. In addition, the cap shall be designed and constructed to prevent infiltration to mitigate potential cross-media migration (soil to groundwater) of COCs. This cap shall be functionally equivalent to the performance standards documented in 40 CFR Section 265.310." (EPA, 2016a)*

5.2 Design Approach

A capping system is a containment technology that forms a barrier between the contamination source and the ground thus minimizing exposure of human and ecological receptors to COCs. It is also typically designed to limit or prevent surface water and rainwater infiltration below the barrier to reduce potential for leaching of COC between subsurface media (soil to groundwater and discharge to surface water).

The performance standards documented in 40 CFR Section 265.310 are as follows:

1. Provide long-term minimization of migration of liquids through the closed landfill;
2. Function with minimum maintenance;
3. Promote drainage and minimize erosion or abrasion of the cover;
4. Accommodate settling and subsidence to maintain the integrity of the cover; and
5. Have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present.

5.3 Design Considerations

One of the key design considerations is the future Site development following installation of the cap. A geomembrane barrier was used for capping the South Parcel Phase 1 to meet the permeability requirements because its future use as a railyard would be covered in a permeable ballast. The subsequent site development resulted in numerous penetrations that were costly and onerous to repair the geomembrane. The cap design used in South Parcel Phase 1 would be technically inappropriate with the future use of South Parcel Phase 2, which will be pier access, truck parking, warehouse facilities, and/ or bulk storage. Construction in Phase 2 will likely require future cap penetrations for storage building footings and light standards. Unlike the rail yard which is a permanent structure for a minimum of the next 30 years, Phase 2 site development may go through multiple site plan changes due to pier customer and storage needs and therefore a capping design that can be readily constructed and repaired is necessary.

On-Site containment will be accomplished by design and construction of an engineered cap. The primary design consideration is that it provides a physical barrier to underlying site contaminants and minimize cross-media transport of contaminants and therefore the hydraulic conductivity needs to be equal or less than the underlying subsurface material. For the Site, the underlying material that requires capping is the fill layer, which ranges from 4 to 20 feet in thickness, and that contains the COPC from surface to 7 feet bgs. The average permeability of the Stratum 1 fill layer is calculated to be 2.18×10^{-5} cm/s (Section 4.4.1)**.**

To improve maintenance of the integrity of cover system during redevelopment, only cover systems that meet the permeability requirements and are readily repairable should be considered. Other considerations include protection from freeze-thaw, durability, ease of maintenance, availability of materials, and cost.

5.4 Proposed Cap Profile

Based on the required cover permeability and the need for simplicity in Site development, a heavy-duty modified asphalt and/or concrete cap are recommended as the proposed cover system for the Phase 2 area of the South Parcel. The COPC are predominantly in the fill material and thus capping the Site with an asphalt and/or concrete-based system will satisfy the functional capping requirements of 40 CFR 265.310 and meet or exceed the permeability requirements of the underlying base (fill) layer.

An asphalt cover system can be installed with multiple layers of hot mix asphalt to create a continuous pavement. The continuity of the asphalt pavement will be achieved by appropriate placement techniques, such as staggering construction joints and placement of liquid asphalt prime coat, also known as fluid applied asphalt (FAA). The FAA layers further reduce permeability and, because they are below grade, do not wear or require maintenance. These design and construction techniques will limit infiltration of stormwater to the underlying fill materials and can be tied into the geomembrane capping system at the existing rail yard.

Future Site development may also include warehouses and other utilitarian buildings of slab-on-grade construction and therefore concrete slabs may also be used as part of the capping system. Its thickness and reinforcement will be determined during the design based on future development needs. A vapor barrier will be included beneath the concrete layer to further reduce permeability and eliminate water migration beneath cracks in the concrete until those cracks are repaired.

A cross-section of the proposed cover system is depicted in **Figure 7**.

The proposed cover system was selected as the preferred remedial approach because it will effectively and consistently minimize long-term risks to human and ecological receptors, minimize infiltration of precipitation and runoff, allow for Site redevelopment use as a truck parking area, warehouse, and/or bulk storage, and provide access to the adjacent pier in the most cost effective manner. In addition, the proposed cover system is durable (i.e., it resists rutting and lateral distortion) and a properly prepared subgrade will reduce differential settlement which will further reduce settlement. This cap design meets the functional capping requirements of 40 CFR 265.310. The proposed cover system (**Figure 7**) will be constructed as follows:

Asphalt Cap

- 6-inch (min) heavy-duty asphalt (4-inch base course plus 2-inch surface course with special reduced air void ratio to 4% and increased asphalt content to reduce permeability);
- An FAA layer will be applied at a uniform rate of 0.35 gallons/square yard, which is equivalent to an average thickness of approximately 60 mils, beneath each course of asphalt;
- 8-inch (min) aggregate, can be compacted recycled concrete or bank run gravel subbase with a maximum particle size of 2.5 inches (Deldot Section 1004); and
- Prepared subgrade can be a variety of surfaces. Soil and gravel will be proof rolled to a firm unyielding surface. Steel or other metal and debris may not be part of the subgrade and will be removed.

Concrete Cap

- 6-inch (min) reinforced concrete. Reinforcement and thickness to be determined with development plan;
- 15-mil vapor barrier;
- 6-inch (min) aggregate, can be compacted recycled concrete or bank run gravel subbase with a maximum particle size of 2.5 inches (Deldot Section 1004); and
- Prepared subgrade, as described above.

The proposed cover system will support future Site development. One of the key design factors in choosing the selected remedy is the requirement that the permeability be less or equal to the that of the underlying soils. A detailed site investigation plan was developed and implemented to better characterize the subsurface strata. Additional remediation elements to be addressed in the cap design include:

- Final grades of 1.5 to 2.0 percent to ensure efficient drainage off the capped area, reduce ponding, and reduce infiltration;

- Detailed drawings illustrating the “tie-ins” at Site boundaries, between asphalt and concrete caps, with the Phase I cap, and with the pending sluiceway and shoreline remedial action being performed by Honeywell and Chemtrade, to ensure consistent cap performance across the Site; and

- An annual inspection and repair program to identify cracks or other issues in the capped area, and repairs to maintain the design permeability of the caps.

5.5 Design Process

The next step in the design process will be to develop the conceptual design. In addition to the grading plan drawings, details on cover system cross sections and tie-in to existing features such as the sluiceway, the Phase 1 cap, and to possible proposed features such as future building foundations and the anticipated shoreline sediment cap, will also be provided.

The design will be supported by infiltration evaluation calculations, as well as settlement calculations. The HELP model may be used to evaluate the thickness of the asphalt and/or concrete capping system. The selected remedy for Phase 2 capping for the Site differs from the Phase 1 capping and thus the design will include updates to the following plans:

- Cap management plan [AECOM, 2017c] to include annual inspections and maintenance for repairs and cracks;
- Materials management plan [AECOM, 2017d];
- Construction quality assurance (CQA) plan [AECOM, 2017d]; and
- Technical specifications.

5.6 Schedule

A project schedule was provided in the PDI Workplan [Geosyntec, 2020]. Generally, the work proceeded according to the schedule but the laboratory analyses were delayed due to work stoppages at the laboratory as a result of the COVID-19 pandemic. A revised schedule for 30%, 90%, and 100% design deliverables and construction implementation is included in **Appendix D.**

6. REFERENCES

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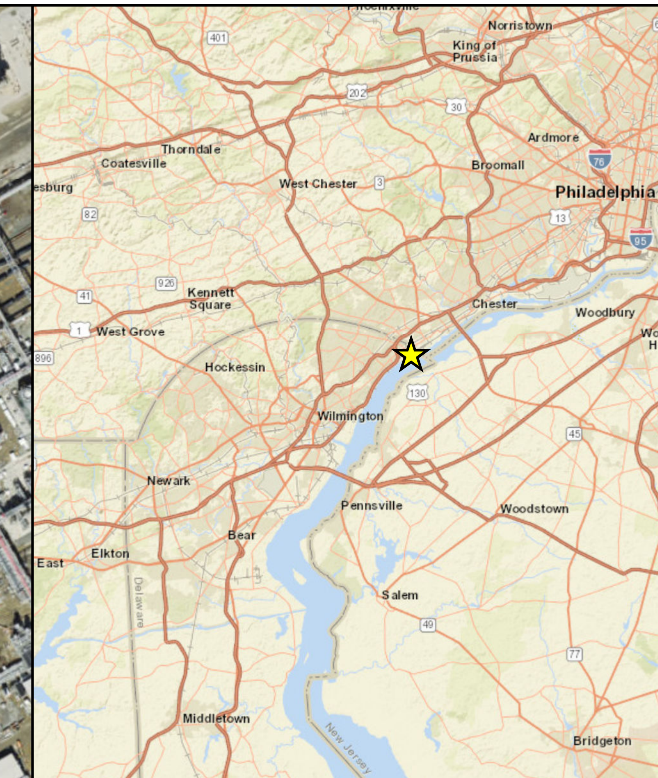
FIGURES



Legend

Facility Boundary

- South Plant North Parcel
- South Plant South Parcel - Phase 1
- South Plant South Parcel - Phase 2 (Project Site)

0 500 Feet

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Site Location Map

Drawbridge Claymont, LLC
Delaware Valley Works Facility, South Plant
Claymont, Delaware

Geosyntec consultants

Ewing, New Jersey | November 2020

Figure 1

P:\GIS\JR0272_Delaware_Valley\Projects\Fig1_SLM.mxd 12/10/2019 2:23:40 PM

Legend

Sample Locations

- Sample Location (2020)
- Historic Boring (2015 Shallow Soil Samples)
- Historic Boring (2015-2016)
- Historic Test Pit (2016)

Facility Boundary

- South Plant North Parcel
- South Plant South Parcel - Phase 1
- South Plant South Parcel - Phase 2 (Site)

Notes:
1. Site boundaries and sample locations are approximate.

0 160 Feet

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Sample Locations

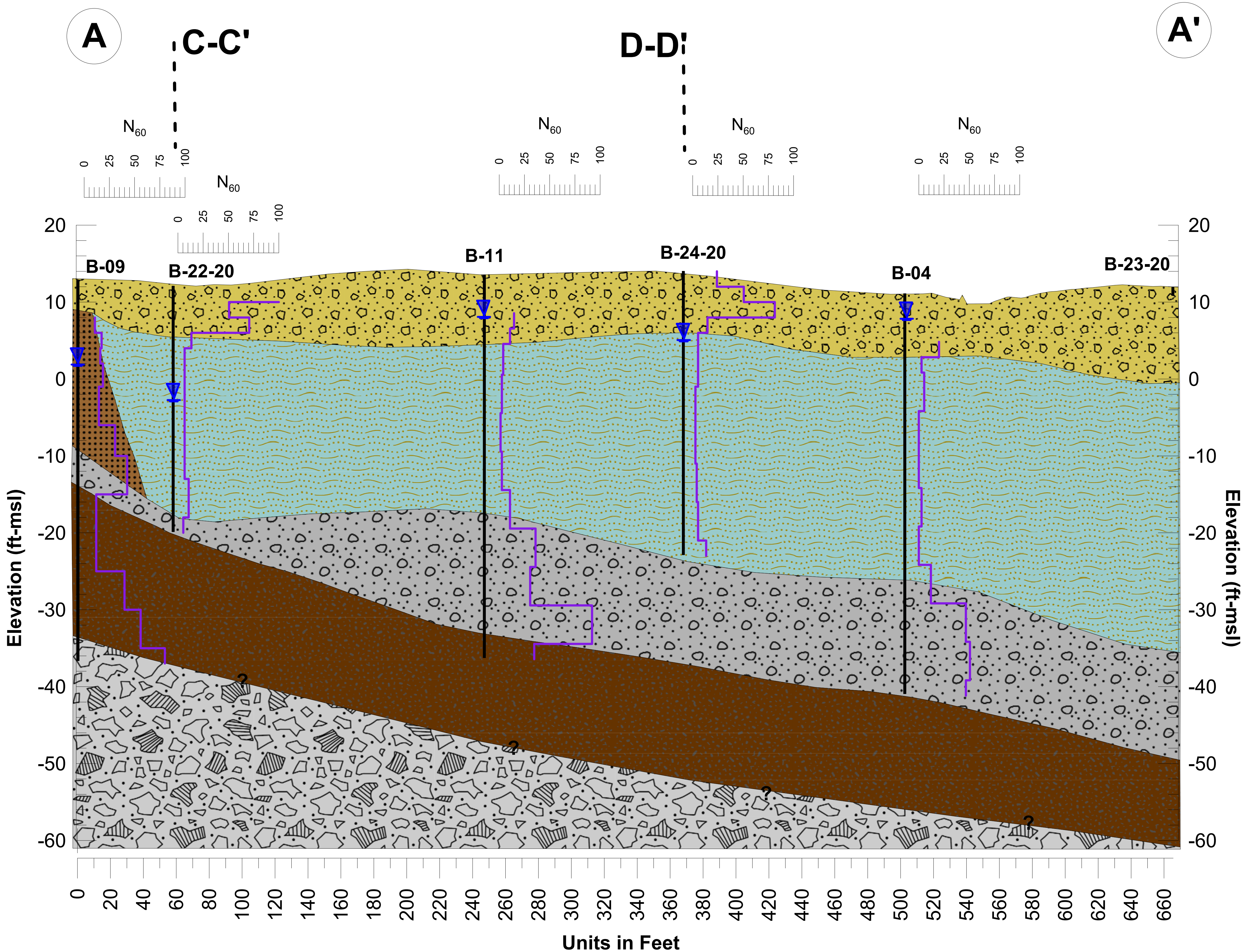
Drawbridge Claymont, LLC
Delaware Valley Works Facility, South Plant
Claymont, Delaware

Geosyntec consultants

Ewing, New Jersey | November 2020

Figure 2

\\columbia-01\Data\GIS\JR0272_Delaware_Valley\Projects\Fig2_Site_Plan_Proposed_Sampling.mxd 2/27/2020 10:02:48 AM



Legend:

Stratum 1: Loose to very dense brown silty sand and gravel (upper),stiff sandy silty clay (lower), with brick, concrete, and wood (FILL)

Stratum 2: Soft to medium stiff dark silty clay and clayey silt, organics

Stratum 3: Stiff to very stiff brown sandy silty clay and clayey silt

Stratum 4: Medium dense to very dense brown and gray silty sand and gravel

Stratum 5: Dense to very dense gray silty sand, very stiff to hard gray sandy silt and silty clay, relict rock structure (RESIDUAL SOIL)

Stratum 6: Very dense gray silty sand, hard gray sandy silty clay and clayey silt, relict rock structure (DECOMPOSED ROCK)

Symbols:

Groundwater table

? Boundary Inferred or Interpreted from boring logs (AECOM 2016 and Geosyntec 2020)

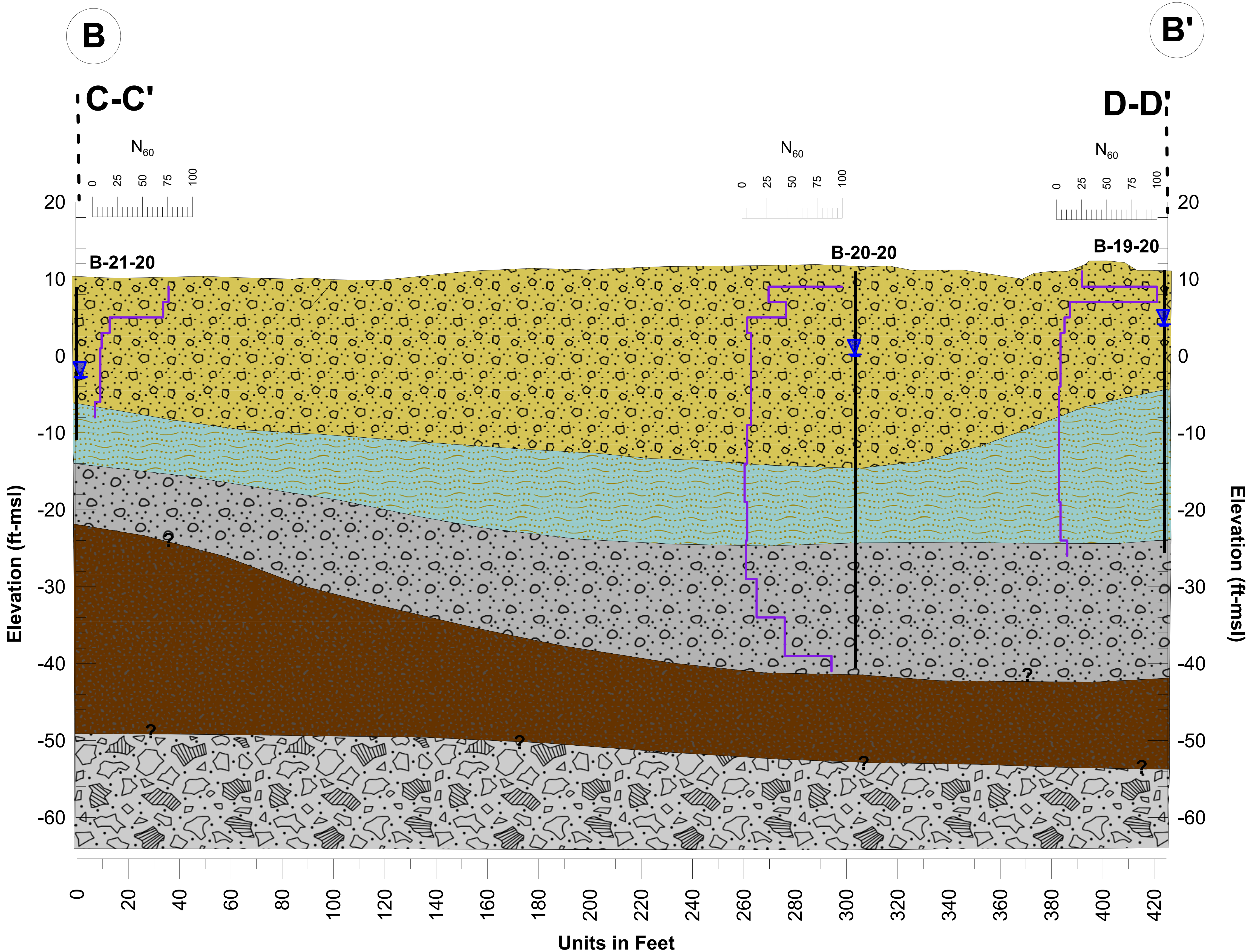
N_{60} Standard Penetration Test blow count corrected by hammer efficiency

Plan view of Sections:

Notes:

1. Boreholes named as B-##-20 were performed by Geosyntec in 2020 while the rests were conducted by AECOM in 2016
2. Surface topography is approximate

Cross Section A-A' Delaware Valley Works South Parcel Claymont, Delaware	
Geosyntec consultants	**FIGURE** 3
Columbia, Maryland — November 2020	



Legend:

Stratum 1: Loose to very dense brown silty sand and gravel (upper),stiff sandy silty clay (lower), with brick, concrete, and wood (FILL)

Stratum 2: Soft to medium stiff dark silty clay and clayey silt, organics

Stratum 3: Stiff to very stiff brown sandy silty clay and clayey silt

Stratum 4: Medium dense to very dense brown and gray silty sand and gravel

Stratum 5: Dense to very dense gray silty sand, very stiff to hard gray sandy silt and silty clay, relict rock structure (RESIDUAL SOIL)

Stratum 6: Very dense gray silty sand, hard gray sandy silty clay and clayey silt, relict rock structure (DECOMPOSED ROCK)

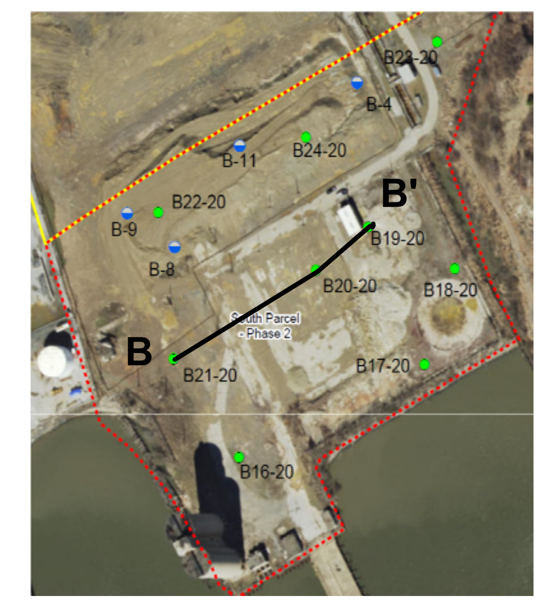
Symbols:

Groundwater table

? Boundary Inferred or Interpreted from boring logs (AECOM 2016 and Geosyntec 2020)

N_{60} Standard Penetration Test blow count corrected by hammer efficiency

Plan view of Sections:



Notes:

1. Boreholes named as B-##-20 were performed by Geosyntec in 2020 while the rests were conducted by AECOM in 2016
2. Stratum 3 does not appear on this cross-section
3. Surface topography is approximate

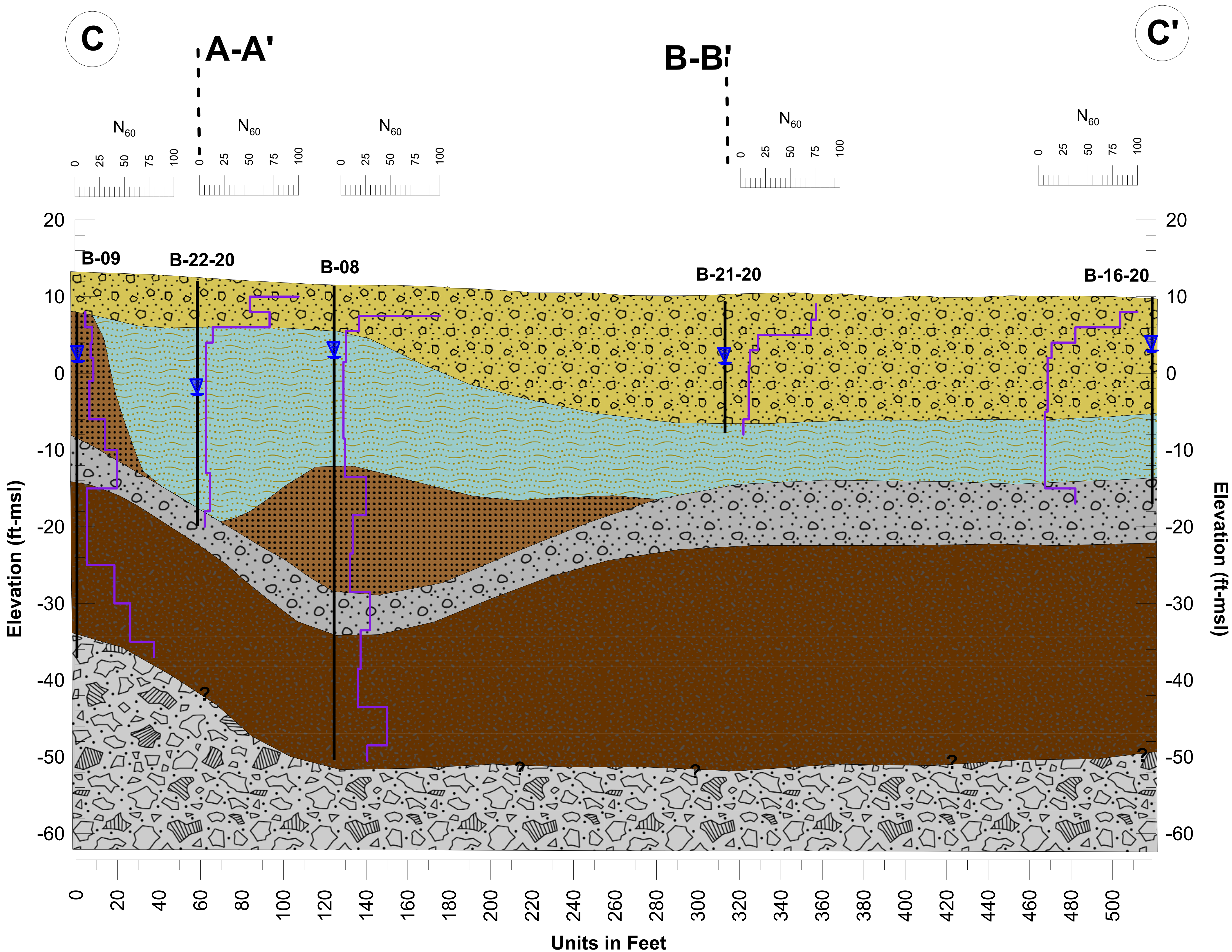
Cross Section B-B'

Delaware Valley Works South Parcel
Claymont, Delaware

Geosyntec consultants

Columbia, Maryland | November 2020

FIGURE 4



Legend:

Stratum 1: Loose to very dense brown silty sand and gravel (upper),stiff sandy silty clay (lower), with brick, concrete, and wood (FILL)

Stratum 2: Soft to medium stiff dark silty clay and clayey silt, organics

Stratum 3: Stiff to very stiff brown sandy silty clay and clayey silt

Stratum 4: Medium dense to very dense brown and gray silty sand and gravel

Stratum 5: Dense to very dense gray silty sand, very stiff to hard gray sandy silt and silty clay, relict rock structure (RESIDUAL SOIL)

Stratum 6: Very dense gray silty sand, hard gray sandy silty clay and clayey silt, relict rock structure (DECOMPOSED ROCK)

Symbols:

Groundwater table

? Boundary Inferred or Interpreted from boring logs (AECOM 2016 and Geosyntec 2020)

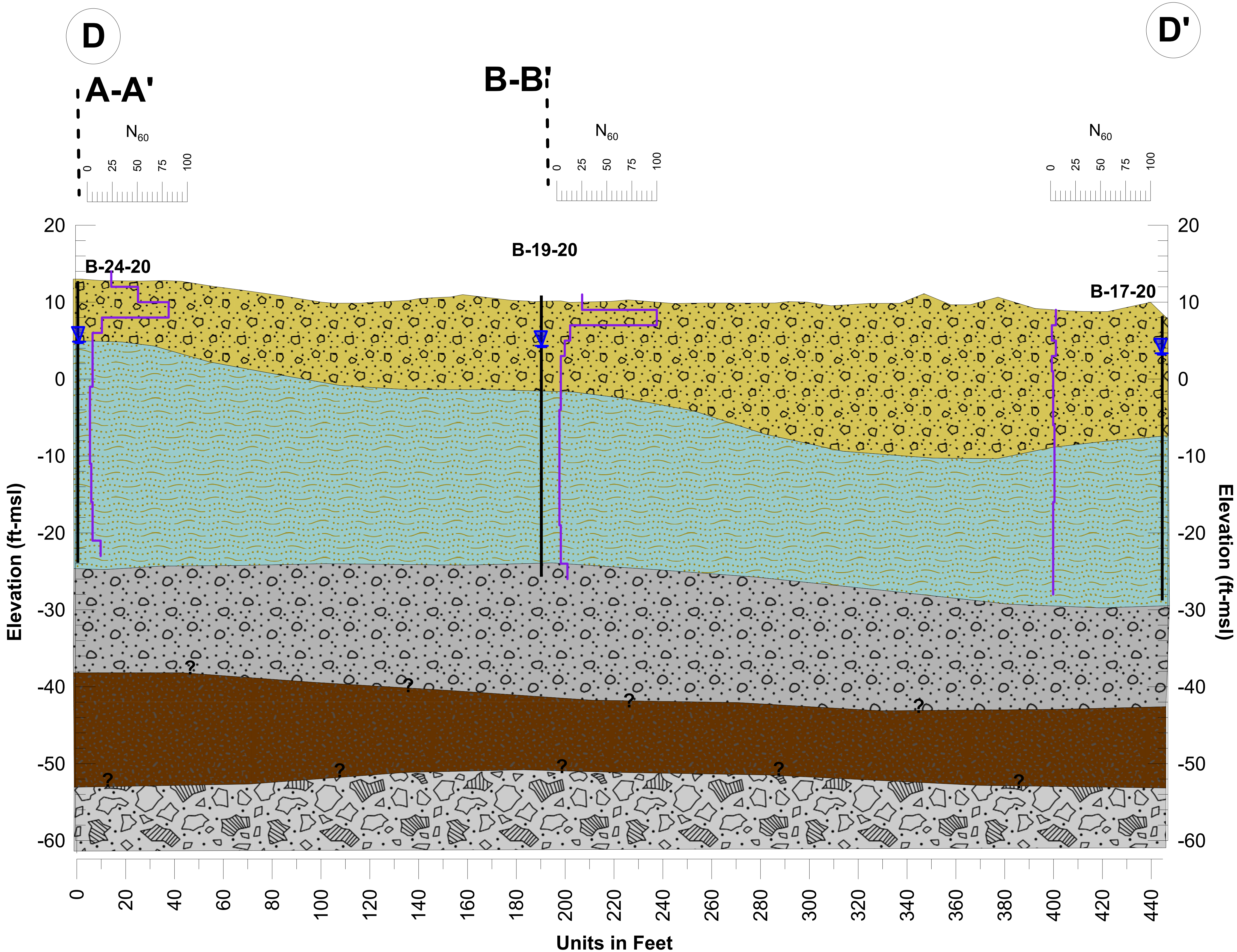
N_{60} Standard Penetration Test blow count corrected by hammer efficiency

Plan view of Sections:

Notes:

1. Boreholes named as B-##-20 were performed by Geosyntec in 2020 while the rests were conducted by AECOM in 2016
2. Surface topography is approximate

Cross Section C-C' Delaware Valley Works South Parcel Claymont, Delaware	
Geosyntec consultants	**FIGURE** **5**
Columbia, Maryland	November 2020



Legend:

Stratum 1: Loose to very dense brown silty sand and gravel (upper), stiff sandy silty clay (lower), with brick, concrete, and wood (FILL)

Stratum 2: Soft to medium stiff dark silty clay and clayey silt, organics

Stratum 3: Stiff to very stiff brown sandy silty clay and clayey silt

Stratum 4: Medium dense to very dense brown and gray silty sand and gravel

Stratum 5: Dense to very dense gray silty sand, very stiff to hard gray sandy silt and silty clay, relict rock structure (RESIDUAL SOIL)

Stratum 6: Very dense gray silty sand, hard gray sandy silty clay and clayey silt, relict rock structure (DECOMPOSED ROCK)

Symbols:

Groundwater table

? Boundary Inferred or Interpreted from boring logs (AECOM 2016 and Geosyntec 2020)

N_{60} Standard Penetration Test blow count corrected by hammer efficiency

Plan view of Sections:

Notes:

1. Boreholes named as B-##-20 were performed by Geosyntec in 2020 while the rests were conducted by AECOM in 2016
2. Stratum 3 does not appear on this cross-section
3. Presence and thickness of strata 4,5, and 6 are based on dat from other cross-sections
4. Surface topography is approximate

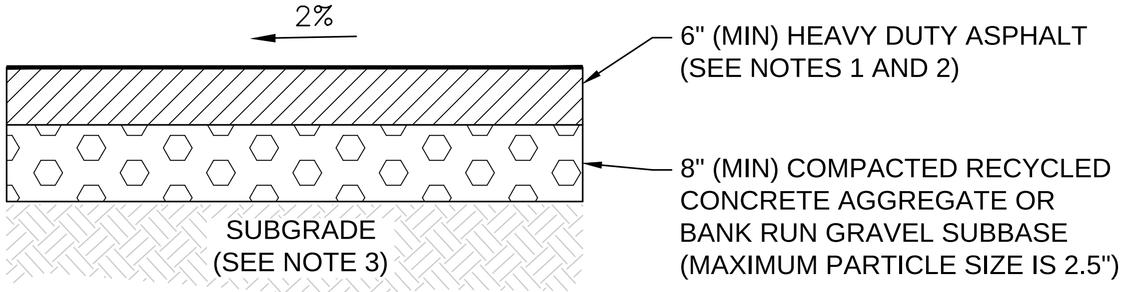
Cross Section D-D'

Delaware Valley Works South Parcel
Claymont, Delaware

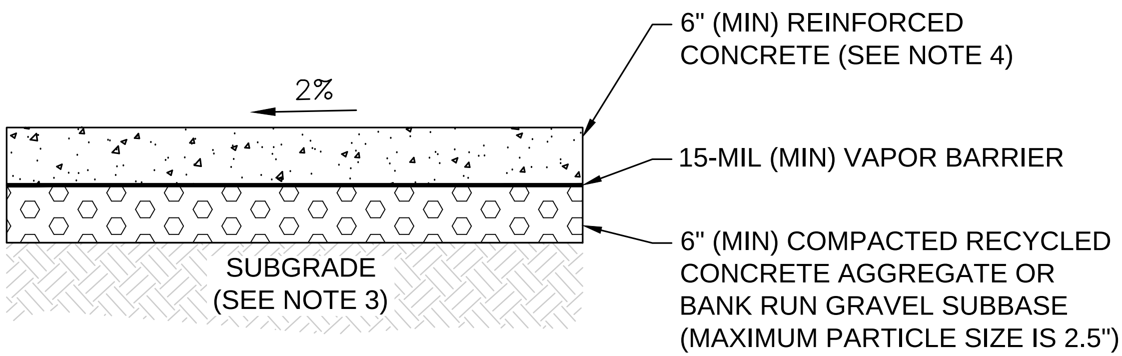
Geosyntec consultants

FIGURE 6

Columbia, Maryland | November 2020



ASPHALT CAP



CONCRETE CAP

NOTES:

1. 6” (MIN) HEAVY DUTY ASPHALT TO BE MADE OF 4” BASE COURSE PLUS 2” SURFACE COURSE WITH SPECIAL REDUCED AIR VOID RATIO TO 4% AND INCREASED ASPHALT CONTENT TO REDUCE PERMEABILITY.

2. A FLUID APPLIED ASPHALT (FAA) LAYER WILL BE APPLIED AT A UNIFORM RATE OF 0.35 GALLONS/SQUARE YARD, WHICH IS EQUIVALENT TO AN AVERAGE THICKNESS OF APPROXIMATELY 60 MILS, BENEATH EACH COURSE OF ASPHALT

3. SUBGRADE MAY BE A VARIETY OF SURFACES. SOIL AND/OR GRAVEL SHALL BE PROOF ROLLED TO A FIRM, UNYIELDING SURFACE. STEEL OR OTHER METAL AND DEBRIS MAY NOT BE PART OF THE SUBGRADE AND WILL BE REMOVED.

4. CONCRETE REINFORCEMENT DESIGN AND THICKNESS TO BE DETERMINED WITH DEVELOPMENT PLAN. WATERSTOPS SHALL BE INSTALLED BETWEEN CONCRETE SECTIONS TO PREVENT INFILTRATION AT JOINTS.

CAPPING CROSS-SECTIONS	
Geosyntec consultants	FIGURE 7
PROJECT NO: JR0272 — NOVEMBER 2020	

TABLES

TABLE 1
SUMMARY OF LAB TESTING PROGRAM

South Parcel, Phase 2, Delaware Valley Works Facility
Claymont, Delaware

Location	Number of Analyses								
	Moisture Content	Atterberg Limits	Hydrometer Analysis	Sieve Analysis	Organic Content	Falling Head Flexible Wall Permeability Test	One-Dimensional Consolidation Test	Isotropically Consolidated Undrained Triaxial Compression Test	Unconsolidated Undrained Triaxial Compression Test
B-16-20	3	2	2	3		1			
B-17-20	2	2	1	1	1	1	1		1
B-18-20	2	1	2	2					
B-19-20	2	1	1	1	1	1		1	
B-20-20	3	2	1	2					
B-21-20	2	2	1	1	1	2		1	
B-22-20	1	1	1	1					
B-23-20	n/a								
B-24-20	3	3	3	3			1		1
Total	18	14	12	14	3	5	2	2	2

n/a - not applicable. Refusal at B-23-20

TABLE 2
SUMMARY OF BORING LOCATIONS

South Parcel, Phase 2, Delaware Valley Works Facility
Claymont, Delaware

Boring ID	Boring Elevation (ft-msl)	Coordinates		Dates Drilled		Total Boring Depth (ft-bgs)	Depth to Water (ft-bgs)	Water Elevation (ft-msl)	Sampling Methods
		Northing (ft)	Easting (ft)	Start	End				
B-01	+10.6	652,068.04	658,154.59	11/20/2015	11/20/2015	52.0	4.6	+6.0	Split Spoon
B-02	+9.5	652,166.83	658,376.48	11/23/2015	11/23/2015	51.0	4.0	+5.5	Split Spoon
B-03	+10.5	651,792.42	658,108.83	11/19/2015	11/19/2015	47.0	6.5	+4.0	Split Spoon
B-04	+10.8	651,847.03	657,788.24	11/19/2015	11/19/2015	52.0	3.2	+7.6	Split Spoon
B-05	+11.0	651,610.49	657,802.05	11/18/2015	11/18/2015	52.0	3.4	+7.6	Split Spoon
B-06	+10.6	651,664.15	657,955.03	11/18/2015	11/18/2015	47.0	4.1	+6.5	Split Spoon Thin-Wall Tube
B-07	+11.1	651,352.59	657,802.86	11/17/2015	11/17/2015	40.4	3.5	+7.6	Split Spoon
B-08	+11.5	651,508.81	657,510.11	11/17/2015	11/17/2015	62.0	10.0	+1.5	Split Spoon
B-09	+13.0	651,420.26	657,566.90	06/28/2016	06/28/2016	50.0	11.5	+1.5	Split Spoon Thin-Wall Tube
B-10	+12.0	651,307.88	657,650.98	06/28/2016	06/28/2016	13.0	10.5	+1.5	Split Spoon
B-11	+13.6	651,628.92	657,681.48	06/28/2016	06/28/2016	50.0	6.0	+7.6	Split Spoon Thin-Wall Tube
B-12	+11.0	651,767.14	657,985.10	06/28/2016	06/28/2016	51.0	4.5	+6.5	Split Spoon Thin-Wall Tube
B-13	+10.9	651,889.93	657,954.70	06/28/2016	06/28/2016	70.0	9.0	+1.9	Split Spoon Thin-Wall Tube
B-14	+10.0	652,074.03	658,052.70	06/28/2016	06/28/2016	51.0	4.0	+6.0	Split Spoon Thin-Wall Tube
B-15	+9.5	652,245.38	658,331.91	06/28/2016	06/28/2016	60.0	4.0	+5.5	Split Spoon Thin-Wall Tube

TABLE 2
SUMMARY OF BORING LOCATIONS

South Parcel, Phase 2, Delaware Valley Works Facility
Claymont, Delaware

Boring ID	Boring Elevation (ft-msl)	Coordinates		Dates Drilled		Total Boring Depth (ft-bgs)	Depth to Water (ft-bgs)	Water Elevation (ft-msl)	Sampling Methods
		Northing (ft)	Easting (ft)	Start	End				
B-16-20	+10.0	651,627.63	657,154.85	02/17/2020	02/17/2020	27.0	7.0	+3.0	Split Spoon Thin-Wall Tube
B-17-20	+9.0	651,970.48	657,312.01	02/18/2020	02/18/2020	37.0	5.0	+4.0	Split Spoon Thin-Wall Tube
B-18-20	+11.0	652,027.57	657,473.75	02/18/2020	02/18/2020	37.0	9.0	+2.0	Split Spoon Thin-Wall Tube
B-19-20	+11.0	651,866.81	657,544.29	02/19/2020	02/19/2020	37.0	7.0	+4.0	Split Spoon Thin-Wall Tube
B-20-20	+11.0	651,770.02	657,471.13	02/19/2020	02/19/2020	52.0	14.5	-3.50	Split Spoon Thin-Wall Tube
B-21-20	+9.0	651,506.24	657,321.19	02/20/2020	02/20/2020	20.0	8.0	+1.0	Split Spoon Thin-Wall Tube
B-22-20	+12.0	651,478.36	657,568.57	02/20/2020	02/21/2020	32.0	15.4	-3.40	Split Spoon Thin-Wall Tube
B-23-20	+12.0	651,994.76	657,856.95	02/21/2020	02/21/2020	1.2	10.1	+1.9	Split Spoon
B-24-20	+14.0	651,751.65	657,695.86	02/21/2020	02/21/2020	37.0	8.3	+5.7	Split Spoon Thin-Wall Tube

Notes:

(1) Ground surface elevation estimated for borings B-16-20 through B-24-20.

(2) For borings where depth to water was not recorded, water table elevation is assumed from the closest boring with depth to water reading.

ft - feet

bgs - below ground surface

msl - mean sea level

APPENDIX A

BORING LOGS

Geosyntec consultants

engineers | scientists | innovators

BORING NUMBER B-16-20

CLIENT Drawbridge Claymont, LLC
PROJECT NAME Delaware Valley Works Facility
PROJECT NUMBER JR0272
PROJECT LOCATION Claymont, DE
DATE STARTED 2/17/20 **COMPLETED** 2/17/20
GROUND ELEVATION 10 ft **HOLE SIZE** 8 inches
DRILLING CONTRACTOR Summit Drilling, Inc.
GROUND WATER LEVELS:
DRILLING METHOD HSA, split spoon, shelby tube
FIELD READING: ---
LOGGED BY T. Murray
NOTES Surface elevations are estimated

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	Depth	MATERIAL DESCRIPTION	Elev.	PID (ppm)
0	SPT	280	50/3"	SP	0.3	(SP) Loose, moist, brown f SAND with organics	9.8	0
				CONCRETE	0.7	(CONCRETE) CONCRETE (crushed); refusal at 0.25'	9.3	0
1					2.0	No recovery	8.0	
2–4	SPT	85	11-30-32-23 (62)	ML	2.8	(ML) Dense to m. dense, moist, purplish dark grey SILT, little light gray f sand mixed in first ~0.5'	7.2	0.5
				SP	3.0	(SP) Loose, moist, dark gray/brown to black f SAND	7.0	0.3
				SM	3.4	(SM) Very dense, moist, light organgish brown f-c SAND mixed with purplish dark gray SILT	6.6	0.3
				CONCRETE	3.7		6.3	
					4.0	(CONCRETE) CONCRETE (broken into "pucks"); red f SAND in shoe	6.0	0
4–6	SPT	45	4-13-15-17 (28)	ML	4.3	(ML) (may be slough) M. dense, moist, purplish dark gray SILT, little f sand, mixed with light gray SILT to f SAND	5.7	1
					4.8	BRICK (crushed), little purplish dark gray SILT mixed in	5.2	
				CONCRETE	4.9	(CONCRETE) CONCRETE (crushed); shoe contains crushed brick, purplish dark gray SILT, and crushed concrete	5.1	0.4
					6.0	No recovery	4.0	
6–8	SPT	25	6-5-5-1 (10)	GW	6.5	(GW) M. dense, wet, red BRICK and brown, light gray, and red f-m SAND	3.5	0
					8.0	No recovery	2.0	
8–10	SPT	63	3-3-4-6 (7)	SW	9.3	(SW) Loose, wet, brown/gray, red, and light brown m SAND, some c sand, little f sand, some f-c gravel (brick)	0.8	0
					10.0	No recovery	0.0	
10–15					15.0		-5.0	

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BORING NUMBER B-16-20

CLIENT Drawbridge Claymont, LLC **PROJECT NAME** Delaware Valley Works Facility

PROJECT NUMBER JR0272 **PROJECT LOCATION** Claymont, DE

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	PID (ppm)
15							
15.2						Likely slough (-5.2)	
16.0	SPT	50	6-3-2-2 (5)	ML		(ML) M. stiff moist, dark brown/gray SILT, some clay, little f sand; 0.9 tsf at 15.5', 0.8 tsf at 15.75' (-6.0)	0.1 6
17.0						No recovery (-7.0)	
18.0						(-8.0)	
20.0	ST	0				Shelby tube; no recovery (-10.0)	
20.5						(-10.5)	
21.5	ST	70		SM		(SM) Shelby tube; refusal at 21.5'; bottom of ST bent; light gray to m. gray SILT and f SAND, some clay, little gravel at bottom of ST (-11.5)	
25.0						(-15.0)	
25.8	SPT	78	8-12-16-19 (28)	SW-SM		(SW-SM) M. dense, wet, gray f SAND and SILT, some f gravel (well-rounded quartz), little clay (-15.8)	0
26.6				SW		(SW) M. dense to dense, wet, gray f-c SAND, some f-m gravel (well-rounded quartz); from ~26.3-26.55' mixed with reddish brown silt, sand, and gravel (sub-angular to well-rounded, reddish brown sandstone with very thin quartz veins) (-16.6)	0 0.2
27.0						No recovery (-17.0)	

Bottom of borehole at 27 feet

BORING NUMBER B-17-20

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CLIENT Drawbridge Claymont, LLC
PROJECT NAME Delaware Valley Works Facility
PROJECT NUMBER JR0272
PROJECT LOCATION Claymont, DE
DATE STARTED 2/18/20 **COMPLETED** 2/18/20
GROUND ELEVATION 9 ft **HOLE SIZE** 8 inches
DRILLING CONTRACTOR Summit Drilling, Inc.
GROUND WATER LEVELS:
DRILLING METHOD HSA, split spoon, shelby tube
FIELD READING: ---
LOGGED BY T. Murray
NOTES Surface elevations are estimated

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	Depth	MATERIAL DESCRIPTION	Elev.	PID (ppm)
0–2	SPT	30	2-2-2-2 (4)	SM	0.6	(SM) Loose, moist, slighty reddish brown f SAND and SILT, some m sand, little c sand, little gravel	8.4	0
					2.0	No recovery	7.0	
2–4	SPT	23	1-0-1-0 (1)	SM	2.5	(SM) Very loose, moist, light reddish brown f SAND, some silt, some m sand, little c sand, little gravel, mixed with little light gray to white clay and silt; dark gray to black f-m sand in shoe	6.6	0
					4.0	No recovery	5.0	
4–6	SPT	55	2-1-3-3 (4)	ML	4.4	(ML) Soft / very loose, moist, reddish brown SILT, little clay, little f-c sand, little gravel	4.7	
				SW	4.4	(SW) Very loose, moist, dark gray m-c SAND and f GRAVEL	4.6	0
				SP	4.9	(SP) Very loose, moist to wet, light brown/gray m SAND, little silt, little clay, little c sand; some yellow m. sand mixed in 4.8-4.9'	4.1	0
				SW	5.1	(SW) Very loose, wet, slightly purplish/reddish brown m SAND, some f sand, some f gravel, some c sand; mixed with light gray/white silt and clay in shoe	3.9	
					6.0	No recovery	3.0	
6–8	SPT	28	2-1-0-1 (1)	SW	6.6	(SW) Very loose, wet, reddish brown m SAND, some c sand, some f gravel, little f sand, piece of wood	2.5	0.1
					8.0	No recovery	1.0	
8–10	SPT	30	1-1-1-0 (2)	SM	8.3	(SM) Very loose / very soft, wet, reddish brown f-c SAND, some f gravel, mixed with dark brown/gray SILT annd f SAND, some clay, wood at 8.2-8.3'	0.7	2.2
				SM	8.6	(SM) Very loose, wet, slightly greenish grown/gray SILT and f SAND, some f-m gravel	0.4	
					10.0	No recovery	-1.0	
15					15.0		-6.0	

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CLIENT Drawbridge Claymont, LLC **PROJECT NAME** Delaware Valley Works Facility
PROJECT NUMBER JR0272 **PROJECT LOCATION** Claymont, DE

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION			PID (ppm)
15.3	SPT	78	4-1-2-2 (3)			15.3	Likely slough; mixture of all lithologies from 8-10'	-6.3	0.2
16				ML			(ML) Soft to m. stiff, moist, gray/brown clayey SILT, little f sand, trace gravel; 0.9 tsf at 16'		2.1
16.6						16.6		-7.6	0.7
17.0						17.0		-8.0	
18.0	ST	0				18.0	Shelby tube; no recovery	-9.0	
20.0						20.0		-11.0	
20.5	ST	140				20.5	Shelby tube	-11.5	
22.5						22.5		-13.5	
25.0	SPT	75	1-1-1-1 (2)			25.0		-16.0	
25.0						25.0	Likely slough	-16.0	
26				ML			(ML) Soft, moist to wet, brown/gray clayey SILT, trace wood/organics; 0.25 tsf at 25.6', 0.3 tsf at 25.8', 0.4 tsf at 26.3'		0 0 0
26.5						26.5	No recovery	-17.5	
27.0						27.0		-18.0	
30.2	SPT	64	1-1-1-1 (2)			30.2	Likely slough	-21.2	
31				CL-ML			(CL-ML) Very soft to soft, wet to moist, brown/gray silty CLAY, trace wood/organics; <0.25 tsf at 31', 0.25 tsf at 31.5'		0 0 0
31.7						31.7		-22.7	
32.0						32.0	No recovery	-23.0	

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BORING NUMBER B-17-20

CLIENT Drawbridge Claymont, LLC

PROJECT NAME Delaware Valley Works Facility

PROJECT NUMBER JR0272

PROJECT LOCATION Claymont, DE

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	PID (ppm)
33							
34							
35						35.0 -26.0	
36	SPT	108	1-1-1-1 (2)	CL-ML		(CL-ML) Soft, wet to moist, brown/gray clayey SILT to silty CLAY, trace wood/organics; 0.4 tsf at 35.8', 36.3', and 36.8'	0 0 0 0
37						37.0 -28.0	

Bottom of borehole at 37 feet

BORING NUMBER B-18-20

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CLIENT Drawbridge Claymont, LLC
PROJECT NAME Delaware Valley Works Facility
PROJECT NUMBER JR0272
PROJECT LOCATION Claymont, DE
DATE STARTED 2/18/20 **COMPLETED** 2/18/20
GROUND ELEVATION 11 ft **HOLE SIZE** 8 inches
DRILLING CONTRACTOR Summit Drilling, Inc.
GROUND WATER LEVELS:
DRILLING METHOD HSA, split spoon, shelby tube
FIELD READING: ---
LOGGED BY T. Murray
NOTES Surface elevations are estimated

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	Layer Depth	MATERIAL DESCRIPTION	Elevation	PID (ppm)
0	SPT	33	3-6-6-4 (12)	SM	0.2	(SM) Loose, moist, brown/gray SILT and f SAND, little m sand, organics	10.8	0
				SW-SM	0.7	(SW-SM) Loose, moist, reddish brown SILT, some f-c sand, some f-c gravel, some clay	10.4	
					2.0	No recovery	9.0	
2	SPT	58	7-13-10-8 (23)	SM	2.4	(SM) M. dense, moist, reddish brown, brown, and yellow to orangish brown SILT and f SAND, trace f gravel	8.6	0
				SW	2.7	(SW) M. dense, moist, brown f-m SAND and gray f-c gravel	8.3	0
				SM	3.2	(SM) Very stiff, moist to dry, orangish/yellowish brown SILT, some f sand, some clay, little gravel	7.9	0
					4.0	No recovery	7.0	
4	SPT	50	7-6-11-10 (17)	SW-SM	4.4	(SW-SM) M. dense, moist, brown/gray SILT and f SAND and gray f-c GRAVEL, organics, mixed with yellowish/orangish SILT, some f sand, some clay at 4.3-4.4'	6.6	0
				SW-SM	5.0	(SW-SM) M. dense, moist, purplish/reddish dark brown/gray and yellowish/orangish SILT and f SAND and gray GRAVEL	6.0	0
					6.0	No recovery	5.0	
6	SPT	58	7-6-3-4 (9)	GW-GM	6.5	(GW-GM) M. dense, moist to wet, brown/gray SILT and f-c GRAVEL, some f-c sand, some clay	4.5	0
				SW	7.2	(SW) Loose, wet to moist, slightly purplish/reddish dark gray to black (some purple/red at 7.05-7.15') f-c SAND, some f gravel, some silt, trace c gravel, trace clay	3.9	0
					8.0	No recovery	3.0	
8	SPT	30	3-2-2-1 (4)		8.3	Likely slough	2.7	0.5
				GW	8.4	(GW) Loose, wet, reddish brown GRAVEL and wood	2.6	
				SW	8.6	(SW) Loose, wet, light yellowish gray f-c SAND and f GRAVEL	2.4	
					10.0	No recovery	1.0	
10–15					15.0		-4.0	

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CLIENT Drawbridge Claymont, LLC
PROJECT NAME Delaware Valley Works Facility
PROJECT NUMBER JR0272
PROJECT LOCATION Claymont, DE

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	PID (ppm)
15							
15.3 / -4.3	SPT	50	5-1-1-1 (2)	SW		(SW) Loose, wet, reddish brown (some yellowish green at 15.25-15.3') m-c SAND and f-c GRAVEL	0
16.0 / -5.0				SW		(SW) Loose, wet, gray (brown at 15.85-16') f-m SAND, some c sand, some f gravel, little silt	
17.0 / -6.0						No recovery	
20.0 / -9.0							
20.2 / -9.2	SPT	100	5-1-1-1 (2)	GW		(GW) (May be slough) loose, wet, greenish brown f GRAVEL and m-c SAND	2.1
20.6 / -9.6				GW-GC		(GW-GC) Soft/loose, wet, gray/brown silty CLAY mixed with greenish brown f GRAVEL and m-c SAND	1.3
22.0 / -11.0				CL-ML		(CL-ML) Very soft to soft, wet, color stratified (light gray, orange, yellow, reddish brown, and dark gray) in ~1-5mm layers, silty CLAY with occasional f SAND layers; <0.25 tsf at 21'	7.6 27.1
24.0 / -13.0							
26.0 / -15.0	ST	113				Shelby tube	
30.0 / -19.0							
32.0 / -21.0	SPT	100	1-1-1-1 (2)	ML		(ML) Soft, wet to moist, brown/gray clayey SILT, trace organics/wood; 0.4 tsf at 30.8' and 31.5', 0.6 tsf at 31.8'	0 0 0 0

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BORING NUMBER B-18-20

CLIENT Drawbridge Claymont, LLC **PROJECT NAME** Delaware Valley Works Facility

PROJECT NUMBER JR0272 **PROJECT LOCATION** Claymont, DE

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	PID (ppm)
33							
34							
35						35.0 -24.0	
36	SPT	108	2-1-1-2 (2)	ML		(ML) Soft, wet to moist, brown/gray clayey SILT, trace organics/wood; 0.4 tsf at 35.6', 0.5 tsf at 36.6'	0 0 0
37						37.0 -26.0	0

Bottom of borehole at 37 feet

BORING NUMBER B-19-20

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CLIENT Drawbridge Claymont, LLC
PROJECT NAME Delaware Valley Works Facility
PROJECT NUMBER JR0272
PROJECT LOCATION Claymont, DE
DATE STARTED 2/19/20 **COMPLETED** 2/19/20
GROUND ELEVATION 11 ft **HOLE SIZE** 8 inches
DRILLING CONTRACTOR Summit Drilling, Inc.
GROUND WATER LEVELS:
DRILLING METHOD HSA, split spoon, shelby tube
FIELD READING: ---
LOGGED BY T. Murray
NOTES Surface elevations are estimated

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	MATERIAL DESCRIPTION	Elev.	PID (ppm)
0.2	SPT	80	6-9-10-10 (19)	ML	(ML) Stiff, moist, dark brown/gray clayey SILT, trace organics	10.9	
0.3				GW	(GW) M. dense, moist, dark gray f-c GRAVEL and brown f SAND, some silt	10.7	0.2
1.6				SM	(SM) Very stiff / m. dense, dry to moist, light brown/gray, purplish brown, and orangish brown SILT, some f sand, some clay, little f gravel, trace organics	9.4	0 / 0.1
2.0					No recovery	9.0	
2.2	SPT	85	12-32-50/5"		Likely slough	8.9	
2.5				ML	(ML) Very stiff, moist, reddish/purplish brown SILT, little f sand, little clay	8.5	0
2.8				ML	(ML) Very stiff, moist, light brown/gray, white, and orangish brown SILT, some clay, some f gravel, little f sand	8.3	
3.0				SW	(SW) Very dense, moist, dark brown/gray c-f SAND, some f gravel	8.0	0
3.2				CONCRETE	(CONCRETE) Very dense, moist to dry, light yellowish brown/gray c-f SAND, some gravel (concrete); refusal at 3.4'	7.8	0
4.0					No recovery	7.0	
4.6	SPT	40	6-5-5-5 (10)	SW	(SW) M. dense, moist, brown/gray, little purplish, and little light to m. yellowish brown/gray f-c SAND, GRAVEL, and SILT, little clay, trace organics	6.5	0
4.7				SM	(SM) M. dense, moist, light yellowish brown/gray SILT, some f-c sand, some gravel, little clay,	6.3	
4.8				SW	(SW) M. dense, moist to dry, light yellowish brown/gray m-c SAND, some f gravel; shoe contains dark brown/gray, light yellowish brown/gray, and red SAND, SILT, and GRAVEL	6.2	0
6.0					No recovery	5.0	
6.6	SPT	28	3-3-3-3 (6)	GW	(GW) Loose, wet, brown/gray f-c GRAVEL, f SAND, and SILT, some m-c sand, little clay, wood; concrete in shoe	4.5	0
8.0					No recovery	3.0	
8.5	SPT	25	3-2-1-1 (3)	GW	(GW) Loose, wet, light yellowish brown/gray GRAVEL (concrete), some m-c sand, wood/organics; sheen on water in spoon	2.5	0
10.0					No recovery	1.0	
15.0						-4.0	

(Continued Next Page)

CLIENT Drawbridge Claymont, LLC **PROJECT NAME** Delaware Valley Works Facility
PROJECT NUMBER JR0272 **PROJECT LOCATION** Claymont, DE

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	PID (ppm)
15.4						Likely slough (-4.4)	
15.4–16.5	SPT	73	1-1-1-1 (2)			Soft, wet to moist, brown/gray clayey SILT, little organics; sheen on water in spoon; 0.5 tsf at 15.75' and 16.2' (-5.5)	0, 0, 0
16.5–17.0						No recovery (-6.0)	
17.0–18.0						(-7.0)	
18.0–20.0	ST	115				Shelby tube; brown/gray clayey SILT, little organics at bottom of ST; 0.75 tsf at 20' (-9.0)	
20.0–20.6	SPT	110	1-1-1-1 (2)			Soft, wet to moist, brown/gray clayey SILT, little organics, little f-m sand (-9.6)	0
20.6–21.2						Loose/soft, wet, brown/gray f-m SAND, little gravel, mixed with some clayey silt, little organics (-10.2)	0
21.2–22.0				CL-ML		(CL-ML) Soft, moist, brown/gray silty CLAY; 0.6 tsf at 21.25', 0.3 tsf at 21.75' (-11.0)	0, 0
22.0–25.0						(-14.0)	
25.0–25.8	SPT	38	2-1-1-1 (2)	CL-ML		(CL-ML) Soft to very soft, wet to moist, brown/gray silty CLAY, little organics; <0.25 tsf at 25.3', 0.25 tsf at 25.7' (-14.8)	0
25.8–27.0						No recovery (-16.0)	0
27.0–30.0						(-19.0)	
30.0–32.0	SPT	105	1-1-2-2 (3)	OL		(OL) Soft to medium stiff, moist to wet, brown/gray silty CLAY to clayey SILT, some organics, trace f-m sand; 0.6 tsf at 30.7', 1 tsf at 31.2' (-21.0)	0, 0, 0, 0

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BORING NUMBER B-19-20

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CLIENT Drawbridge Claymont, LLC
PROJECT NAME Delaware Valley Works Facility
PROJECT NUMBER JR0272
PROJECT LOCATION Claymont, DE

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	PID (ppm)
33							
34							
35						35.0 -24.0	
35–37	SPT	105	2-4-4-6 (8)	SM		(SM) M. stiff to stiff, moist to wet, brown/gray SILT, some clay, some f sand, little gravel at 35-36.5', little organics at 35-35.5'; f sand increases with depth slightly; 0.4 tsf at 35.4', 1.4 tsf at 36.25'	0 0 0 0
37						37.0 -26.0	

Bottom of borehole at 37 feet

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CLIENT Drawbridge Claymont, LLC
PROJECT NAME Delaware Valley Works Facility
PROJECT NUMBER JR0272
PROJECT LOCATION Claymont, DE
DATE STARTED 2/19/20 **COMPLETED** 2/19/20
GROUND ELEVATION 11 ft **HOLE SIZE** 8 inches
DRILLING CONTRACTOR Summit Drilling, Inc.
GROUND WATER LEVELS:
DRILLING METHOD HSA, split spoon, shelby tube
FIELD READING: ---
LOGGED BY T. Murray
NOTES Surface elevations are estimated

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	DEPTH	MATERIAL DESCRIPTION	ELEV.	PID (ppm)
0	SPT	600	50/1"	SW-SM	0.1	(SW-SM) Loose, moist, brown/gray f-m SAND and SILT, little clay, little organics	10.9	0
				CONCRETE	0.5	(CONCRETE) CONCRETE; refusal at 0.25'	10.5	
1						No recovery		
2					2.0		9.0	
	SPT	40	6-8-12-18 (20)	SW-SM	2.3	(SW-SM) M. dense, moist, brown/gray to dark brown/gray f-c SAND and SILT, some f-c gravel	8.7	0
				CONCRETE	2.4	(CONCRETE) CONCRETE	8.6	
3				SW-SM	2.8	(SW-SM) M. dense, dry to moist, light orangish brown f SAND and SILT and gray f GRAVEL (concrete)	8.2	0
						No recovery		
4					4.0		7.0	
	SPT	88	5-15-18-15 (33)		4.2	Likely slough	6.8	
5				ML		(ML) Dense, dry to moist, orangish brown SILT, little f gravel, little f-c sand		0
								0
								0
					5.8		5.3	
6					6.0		5.0	
	SPT	68	4-2-2-3 (4)		6.2	Likely slough	4.8	
				ML	6.6	(ML) Loose, dry to moist, orangish brown SILT, some f sand	4.4	0
7				CL-ML	6.9	(CL-ML) M. stiff, moist, very light gray clayey SILT	4.2	0
				SW-SM	7.3	(SW-SM) Very loose, moist, orangish brown f SAND and SILT, some clay, little gravel, dark gray at 7.1-7.2'	3.7	0
				SM	7.4	(SM) Very loose, moist, gray f-m SAND, some silt, some clay; dark gray to black in bottom of shoe	3.7	
8					8.0	No recovery	3.0	
	SPT	80	4-3-4-6 (7)	ML	8.6	(ML) Loose, moist, orangish brown SILT, some f sand, some clay, little m-c sand, little f gravel	2.5	0
9				SW		(SW) Loose, wet, dark brown f-m SAND, some gravel (brick), little silt		0
					9.6	No recovery	1.4	0
10					10.0		1.0	
11								0
12								
13								
14								
15					15.0		-4.0	

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BORING NUMBER B-20-20

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CLIENT Drawbridge Claymont, LLC **PROJECT NAME** Delaware Valley Works Facility

PROJECT NUMBER JR0272 **PROJECT LOCATION** Claymont, DE

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	PID (ppm)
15.2	SPT	28	8-4-3-4 (7)			Likely slough (-4.2)	
15.4				ML		(ML) M. dense, moist to dry, orangish brown SILT, some f sand, some clay (-4.4)	
15.6				SW		(SW) M. dense, wet, dark brown/gray to black f-m SAND, some gravel (some brick among gravel), some silt, little wood (-4.6)	
						No recovery	
17.0						(-6.0)	
20.0						(-9.0)	
20.2	SPT	10	4-1-3-1 (4)	SW		(SW) Loose, wet, light gray mixed with dark gray f-m SAND, some f gravel, little silt, trace clay (-9.2)	0
						No recovery	
22.0						(-11.0)	
25.0						(-14.0)	
25.6	SPT	65	3-1-1-1 (2)	SW		(SW) Loose, wet, dark brown/gray and some orangish brown f-c SAND, some f gravel, some silt, mixed with dark brown/gray clayey silt (-14.6)	0
26.3						Soft, moist, dark/brown gray clayey SILT, trace organics; 0.5 fsf at 25.7', 0.4 tsf at 26.1' (-15.3)	0
						No recovery	0
27.0						(-16.0)	
28.0						(-17.0)	
	ST	46				Shelby tube	
30.0						(-19.0)	
31.0	SPT	50	1-2-2-2 (4)	OL		(OL) Soft, moist, dark brown/gray clayey SILT and wood, little f sand (-20.0)	0
						No recovery	0
32.0						(-21.0)	

(Continued Next Page)

BORING NUMBER B-20-20

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CLIENT Drawbridge Claymont, LLC
PROJECT NAME Delaware Valley Works Facility
PROJECT NUMBER JR0272
PROJECT LOCATION Claymont, DE

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	Top Depth	MATERIAL DESCRIPTION	Elevation	PID (ppm)
33									
34									
35						35.0		-24.0	
35.0–35.5	SPT	90	1-1-2-4 (3)	ML		35.5	(ML) Soft, wet, brown/gray clayey SILT, little f-m sand, some organics/wood	-24.5	0
35.5–36.8				SW		36.8	(SW) Soft / very loose, wet, alternating layers of dark brown clayey SILT, f GRAVEL, f-c SAND, and some general mixing of the above lithologies throughout; layers are mostly less than or equal to 0.1' thick, except 36.5-36.8' is distinctly m, f, c SAND	-25.8	0 0 0
36.8–37.0						37.0	No recovery	-26.0	0
38									
39									
40						40.0		-29.0	
40.0–40.2	SPT	100	4-5-6-7 (11)			40.2	Likely slough	-29.2	
40.2–40.8				SW-SM		40.8	(SW-SM) Loose, wet, brown/gray f SAND and SILT, some clay, some m sand	-29.8	0
40.8–40.9				SP		40.9	(SP) Loose, wet, brown/gray f SAND	-29.9	0
40.9–41.9				SW		41.9	(SW) M. dense, wet, brown/gray m-c SAND (mostly well- to sub-rounded), trace f gravel	-30.9	0
41.9–42.0						42.0	M. dense, wet, brown/gray m-f SAND	-31.0	0
43									
44									
45						45.0		-34.0	
45.0–45.4	SPT	73	15-18-14-9 (32)	SP		45.4	(SP) M. dense, wet, brown/gray m SAND	-34.4	
45.4–45.5				SP		45.5	(SP) M. dense, wet, brown/gray f SAND and wood, trace f gravel (well-rounded quartz)	-34.5	0
45.5–46.5				SW		46.5	(SW) Dense, wet, orangish brown m-f SAND, some f-c gravel (well-rounded to sub-angular, mostly quartz), little silt, trace clay, some c sand	-35.5	0 0
46.5–47.0						47.0	No recovery	-36.0	
48									
49									

(Continued Next Page)

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BORING NUMBER B-20-20

CLIENT Drawbridge Claymont, LLC **PROJECT NAME** Delaware Valley Works Facility

PROJECT NUMBER JR0272 **PROJECT LOCATION** Claymont, DE

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	PID (ppm)
50						50.0 ... -39.0	
	SPT	65	13-31-36-24 (67)	SW		50.4 (SW) M. dense, wet, brown/gray f-c SAND, some silt, little clay -39.4	0
51				GW		50.5 (GW) Dense, wet, WOOD and c GRAVEL (sub-angular) -39.5	0
				SW		51.3 (SW) Very dense, wet, very slightly greenish brown/gray, orangish brown, and occassionally purple f-c SAND, SILT, and GRAVEL (quartz and heavily weathered rock) -40.3	0
52						52.0 No recovery -41.0	

Bottom of borehole at 52 feet

GENERAL BH / TP / WELL - 2 - GEOSYNTECNJ_STD.GDT - 8/21/20 08:16 - P:\PRJ1\DATABASE\GINT\PROJECTS\JR0272 - DVW\PRE-DESIGN INVESTIGATION BORINGS.GPJ

BORING NUMBER B-21-20

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CLIENT Drawbridge Claymont, LLC
PROJECT NAME Delaware Valley Works Facility
PROJECT NUMBER JR0272
PROJECT LOCATION Claymont, DE
DATE STARTED 2/20/20 **COMPLETED** 2/20/20
GROUND ELEVATION 9 ft **HOLE SIZE** 8 inches
DRILLING CONTRACTOR Summit Drilling, Inc.
GROUND WATER LEVELS:
DRILLING METHOD HSA, split spoon, shelby tube
FIELD READING: ---
LOGGED BY T. Murray
NOTES Surface elevations are estimated

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	Depth (ft)	MATERIAL DESCRIPTION	Elev. (ft)	PID (ppm)
0	SPT	78	5-22-35-31 (57)	SW	0.1	(SW) Loose, moist, brown f-c SAND, SILT, and GRAVEL, some organics	8.9	
				SW	1.1	(SW) M. dense, moist, brown to slightly orangish brown to dark brown f SAND and SILT, some gravel, some m-c sand, wood at 0.3 to 0.4'	8.0	0
1				SW	1.4	(SW) Very dense, orangish brown and light reddish/purplish brown/gray m-c SAND and GRAVEL; gravel crumbles fairly easily and has an appearance like that of weathered rock	7.6	0
				GW	1.6	(GW) Very dense, gray to dark gray GRAVEL with white veins (likely quartz) and f-c sand (crushed rock)	7.5	0
					2.0	No recovery	7.0	
2	SPT	63	17-22-31-21 (53)	SW	2.4	(SW) Dense, moist, orangish brown and brown f-c SAND, some f-c gravel, little silt; boulder at 2'	6.6	
				SW	2.9	(SW) Dense, moist, brown f-c SAND and gray f-c GRAVEL, little silt	6.1	
3				ML	3.2	(ML) Hard, moist, reddish purple SILT	5.9	
				ML	3.3	(ML) Hard, moist, black and some white SILT	5.8	
					4.0	No recovery	5.0	
4	SPT	75	6-8-5-7 (13)	SW-SM	4.3	(SW-SM) M. dense, moist, lightish brown/gray SILT, some f sand, some clay, little f gravel	4.7	
				SW-SM	4.9	(SW-SM) M. dense, moist, brown/gray, light orangish brown, and very light tan SILT and f SAND, some f-c gravel, some m-c sand, little clay	4.2	
5				SM	5.1	(SM) M. dense, moist, brownish gray f SAND, some silt, little m-c sand, little f gravel	4.0	
				SW	5.5	(SW) M. dense, dry to moist, reddish purple f-c SAND	3.5	
					6.0	No recovery	3.0	
6	SPT	23	1-3-4-3 (7)	SW	6.2	(SW) Loose, wet, brown/gray SILT, f-c SAND, GRAVEL, some clay, little organics	2.8	
				GW	6.5	(GW) Loose, wet, red/brown gravel- to sand-sized BRICK	2.6	0
7					8.0	No recovery	1.0	
8	SPT	25	1-3-3-3 (6)	SW-SM	8.5	(SW-SM) Loose, wet, dark brown/gray to black SILT, f SAND, and organics, some clay, little f gravel; NAPL floating on water throughout spoon; petroleum hydrocarbon odor	0.5	5.6
9					10.0	No recovery	-1.0	
10								

(Continued Next Page)

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BORING NUMBER B-21-20

CLIENT Drawbridge Claymont, LLC

PROJECT NAME Delaware Valley Works Facility

PROJECT NUMBER JR0272

PROJECT LOCATION Claymont, DE

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	PID (ppm)
10–15							
15.0–17.0	SPT	55	4-1-1-1 (2)	SW-SM		15.0 / 15.2 (SW-SM) Loose, wet, tan, brown/gray, and red f-c SAND, some f gravel mixed with brown clayey SILT, some organics -6.0 / -6.2	0
				ML		(ML) M. stiff, moist, brown clayey SILT, some organics; 1.25 tsf at 15.4', 1 tsf at 15.9' 16.1 -7.1	0
						No recovery 17.0 -8.0	
17.0–18.0						18.0 -9.0	
18.0–20.0	ST	110		OL		(OL) Shelby tube; brown WOOD and SILT/CLAY at bottom of ST 20.0 -11.0	

Bottom of borehole at 20 feet

BORING NUMBER B-22-20

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CLIENT Drawbridge Claymont, LLC
PROJECT NAME Delaware Valley Works Facility
PROJECT NUMBER JR0272
PROJECT LOCATION Claymont, DE
DATE STARTED 2/20/20 **COMPLETED** 2/21/20
GROUND ELEVATION 12 ft **HOLE SIZE** 8 inches
DRILLING CONTRACTOR Summit Drilling, Inc.
GROUND WATER LEVELS:
DRILLING METHOD HSA, split spoon, shelby tube
FIELD READING: ---
LOGGED BY T. Murray
NOTES Surface elevations are estimated

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.
0 - 0.7	SPT	38	22-50/2"	SW-SM
2 - 4	SPT	90	7-21-17-43 (38)	SW-SM, SW-SM, SW, GW-GM
4 - 6	SPT	83	7-37-16-25 (53)	GW-GM
6 - 8	SPT	90	4-5-5-7 (10)	GW-GM, ML
8 - 10	SPT	73	2-2-3-5 (5)	ML

Depth	MATERIAL DESCRIPTION	Elev.	PID (ppm)
0.3	(SW-SM) Dense, moist, grayish brown SILT and f SAND, little m-c sand, little gravel, little clay, trace muscovite flakes; refusal at 0.7' likely on concrete	11.8	0
	No recovery		
2.0		10.0	
2.5	(SW-SM) M. dense, moist, grayish brown SILT and f SAND, little clay, little m-c sand, little gravel, trace muscovite flakes	9.6	0
2.6		9.4	
2.8	M. dense, gray, black, and pink GRAVEL (drilled through large piece of gneiss)	9.2	
3.0	(SW-SM) Dense, moist, slightly orangish brown f SAND and SILT, some clay, some f gravel, some m-c sand	9.1	0.2
3.1		9.0	
3.4		8.6	28.5
3.8	(SW) Dense, dry to moist, brown f-c SAND, some silt, some f gravel	8.2	
4.0	Dense, red BRICK	8.0	0.5
4.4	Dense, WOOD	7.6	0
	(GW-GM) Very dense, dry to moist, black SILT mixed with red brick gravel and light gray gravel		0
	No recovery		0
5.7	Likely slough	6.4	
6.0	(GW-GM) Very dense, dry to moist, black SILT mixed with red BRICK, concrete at 4.75-4.85', some brown silt mixed in at 5.2-5.45'	6.0	0
6.5	No recovery	5.5	0
6.6	Likely slough	5.4	0
	(GW-GM) Loose, dry-moist, black SILT and red BRICK		
7.8	(ML) Stiff, dry to moist, very slightly greenish/blueish gray clayey SILT, some f sand; 2.25 tsf at 7.3'	4.2	0
8.0	No recovery	4.0	
8.3	Slough	3.7	
9.5	(ML) M. stiff, dry to moist, very slightly greenish/blueish gray clayey SILT, some f sand, trace m sand, at 9.35-9.45' more sand, less clay, trace f gravel (well-rounded); 1.25 tsf at 8.7'	2.6	0, 0, 0
10.0	No recovery	2.0	
15.0		-3.0	

(Continued Next Page)

BORING NUMBER B-22-20

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CLIENT Drawbridge Claymont, LLC
PROJECT NAME Delaware Valley Works Facility
PROJECT NUMBER JR0272
PROJECT LOCATION Claymont, DE

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION			PID (ppm)
15									
15–17	SPT	98	2-2-3-5 (5)	ML		(ML) M. stiff, dry to moist, gray clayey SILT, some f sand, little organics, trace m sand; small sections of orangish brown throughout, darker brown/gray at 16.45-16.95'; 3 tsf at 15.85', 2 tsf at 16.7'	17.0	-5.0	
17.0–18.0						No recovery	17.0	-5.0	
18–20				ML		(ML) Shelby tube; brown/gray clayey SILT, little to some organics at bottom of ST	18.0 / 20.0	-6.0 / -8.0	
20–22	SPT	45	1-1-4-5 (5)	ML		(ML) M. stiff, moist to dry, dark brown/gray clayey SILT, little to some organics, little f sand, slough mixed in at 20-20.3'; 1.25 tsf at 20.3', 0.9 tsf at 20.7'	20.9	-8.9	0 0
						No recovery	22.0	-10.0	
22–25							25.0	-13.0	
25–27	SPT	100	2-3-5-7 (8)	ML		(ML) M. stiff, moist to dry, brown/gray clayey SILT, little to some organics, little f sand; 0.7 tsf at 25.2'; slough mixed in at 25-25.1'	25.5	-13.5	0
				ML		(ML) M. stiff, dry to moist, gray SILT, some clay, some f sand; 4.2 tsf at 26', 4.75 tsf at 26.6'	27.0	-15.0	0 0 0
27–30							30.0	-18.0	
30–32	SPT	100	1-2-2-1 (4)	ML		(ML) Soft, moist, dark brown/gray clayey SILT, little to some organics	30.2	-18.2	
				ML		(ML) Soft, moist, gray SILT, some clay, some f sand	30.5	-18.5	0
				SW		(SW) Very loose, wet, very slightly orangish brown f-m SAND, some f-c gravel, some c sand, little silt, little clay	32.0	-20.0	0 0 0

Bottom of borehole at 32 feet

BORING NUMBER B-23-20

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CLIENT Drawbridge Claymont, LLC
PROJECT NAME Delaware Valley Works Facility
PROJECT NUMBER JR0272
PROJECT LOCATION Claymont, DE
DATE STARTED 2/21/20 **COMPLETED** 2/21/20
GROUND ELEVATION 12 ft **HOLE SIZE** 8 inches
DRILLING CONTRACTOR Summit Drilling, Inc.
GROUND WATER LEVELS:
DRILLING METHOD HSA, split spoon, shelby tube
FIELD READING: ---
LOGGED BY T. Murray
NOTES Surface elevations are estimated

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	Depth	MATERIAL DESCRIPTION	Elev.	PID (ppm)
0	SPT	86	7-7-50/2"	SW-SM		0.2	(SW-SM) M. dense, moist to wet, brown f SAND and SILT, some m-c sand, some f gravel, little clay	11.8	0
				SW		0.6	(SW) M. dense, moist, light yellowish brown f-m SAND	11.5	
				GW		0.7	(GW) M. dense, moist, brown/gray GRAVEL, some brown f sand, some silt	11.3	
1				ML		1.0	(ML) Dense, moist, very light tan SILT, f SAND, and CLAY	11.0	0
						1.2	No recovery; refusal at 1.2' likely on large concrete slab	10.8	

Bottom of borehole at 1.2 feet

BORING NUMBER B-24-20

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CLIENT Drawbridge Claymont, LLC
PROJECT NAME Delaware Valley Works Facility
PROJECT NUMBER JR0272
PROJECT LOCATION Claymont, DE
DATE STARTED 2/21/20 **COMPLETED** 2/21/20
GROUND ELEVATION 14 ft **HOLE SIZE** 8 inches
DRILLING CONTRACTOR Summit Drilling, Inc.
GROUND WATER LEVELS:
DRILLING METHOD HSA, split spoon, shelby tube
FIELD READING: ---
LOGGED BY T. Murray
NOTES Surface elevations are estimated

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	Depth	MATERIAL DESCRIPTION	Elev.	PID (ppm)
0–2	SPT	80	8-11-7-18 (18)	SW-SM		(SW-SM) M. dense, moist, brown f SAND and SILT, some m-c sand, little clay, little muscovite flakes, little f gravel, trace brick, c gravel at 1-1.2'; black silt and brick in shoe		0, 0, 0
					1.6		12.4	
					2.0	No recovery	12.0	
2–4	SPT	35	11-21-17-19 (38)		2.1	Likely slough	11.9	0, 0
				SW	2.5	(SW) M. dense, dry to moist, red BRICK (gravel and crushed), black SILT and f SAND, some organics	11.5	
				SW	2.7	(SW) Dense, dry to moist, light gray GRAVEL and brown f SAND and SILT, some m-c sand, some red brick, some light gray f-m sand and silt (crushed gravel), little organics	11.3	
					4.0	No recovery	10.0	
4–6	SPT	70	10-28-33-16 (61)	SW	4.1	Slough	9.9	0, 0, 0
				SW	4.3	(SW) M. dense, dry, red crushed BRICK (f-c sand-sized) and brown/gray f-c SAND, little organics	9.7	
					4.4		9.6	
					5.0		9.1	
				GW		M. dense, BRICK and CONCRETE (fused together) in puck shapes		
					5.4	(SW) Very dense, dry to moist, dark to m. brown/gray f-c SAND, some f gravel, little silt	8.6	
					6.0	(GW) Very dense, dry to moist, gray GRAVEL, some slightly yellowish brown f-c sand	8.0	
6–8	SPT	65	4-8-3-6 (11)	SW	6.3	Likely slough	7.7	0, 0
					6.9	(SW) M. dense, dry to moist, black to dark gray f-c SAND, little f gravel, trace c gravel	7.1	
				ML	7.1		6.9	
				SW	7.3	(ML) Stiff, dry to moist, slightly yellowish brown SILT, little clay	6.7	
						(SW) M. dense, moist to wet, black m SAND, some c sand, some gravel		
					8.0		6.0	
8–10	SPT	78	5-2-2-2 (4)	ML	8.1	No recovery	5.9	0, 0, 0
					8.4	Slough	5.7	
				ML		(ML) Loose, moist to wet, black m SAND, some c sand, some gravel		
						(ML) Soft, moist to wet, gray to dark gray SILT, some clay, some f-m sand, trace f gravel, occassional brown f-m sand mixed in		
					9.6	No recovery	4.5	
10–13					10.0	Shelby tube; no recovery	4.0	
					12.0		2.0	
					13.0		1.0	
13–15	ST	117		ML		(ML) Shelby tube; gray to dark gray SILT, some clay, some f-m sand, trace f gravel at bottom of ST		
					15.0		-1.0	

(Continued Next Page)

BORING NUMBER B-24-20

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CLIENT Drawbridge Claymont, LLC
PROJECT NAME Delaware Valley Works Facility
PROJECT NUMBER JR0272
PROJECT LOCATION Claymont, DE

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	PID (ppm)
15							
15.0–15.6	SPT	58	3-1-1-2 (2)	ML		(ML) M. stiff, wet, gray to dark gray SILT, some clay, some f-m sand, trace f gravel 15.6 -1.6	
15.6–16.2				OL		(OL) Soft, moist, WOOD, some dark brown/gray clayey SILT 16.2 -2.2	
16.2–17.0						No recovery 17.0 -3.0	
17.0–20.0						20.0 -6.0	
20.0–22.0	SPT	105	1-1-1-1 (2)	ML		(ML) Soft, moist, dark brown/gray clayey SILT, little organics, wood at 20.2-20.3'; 0.8 tsf at 21.3', 0.75 tsf at 21.8' 22.0 -8.0	0 0 0 0
22.0–25.0						25.0 -11.0	
25.0–27.0	SPT	100	1-1-2-2 (3)	ML		(ML) Soft, moist, dark brown/gray clayey SILT, little organics; WOOD and f-m SAND at 25.3-25.4'; 0.75 tsf at 25.9', 0.75 tsf at 26.3', 26.5 tsf at 26.75' 27.0 -13.0	0 0 0 0
27.0–30.0						No recovery 30.0 -16.0	
30.0–32.0	SPT	100	2-2-2-2 (4)	ML		(ML) Soft, moist, dark brown/gray clayey SILT, little organics; 1 tsf at 30.5', 1.2 tsf at 31.4' 32.0 -18.0	0 0 0 0

(Continued Next Page)

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BORING NUMBER B-24-20

CLIENT Drawbridge Claymont, LLC

PROJECT NAME Delaware Valley Works Facility

PROJECT NUMBER JR0272

PROJECT LOCATION Claymont, DE

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	PID (ppm)
33 34 35						No recovery *(continued)* 35.0 -21.0	
	SPT	100	4-5-5-5 (10)	ML		(ML) M. stiff, moist, dark brown/gray clayey SILT, little organics 35.6 -21.6	0
36 37				ML		(ML) Stiff, dry to moist, fairly light to medium very slightly reddish brown/gray SILT, some clay, trace f gravel (well-rounded) occasional lenses containing very slightly greenish gray f-m SAND, rare lenses of reddish brown and slightly purplish brown f-m sand; lenses do not occupy full diameter of core; 36.95-37' is a single piece (full diameter) slightly greenish gray rock 37.0 -23.0	0 0 0

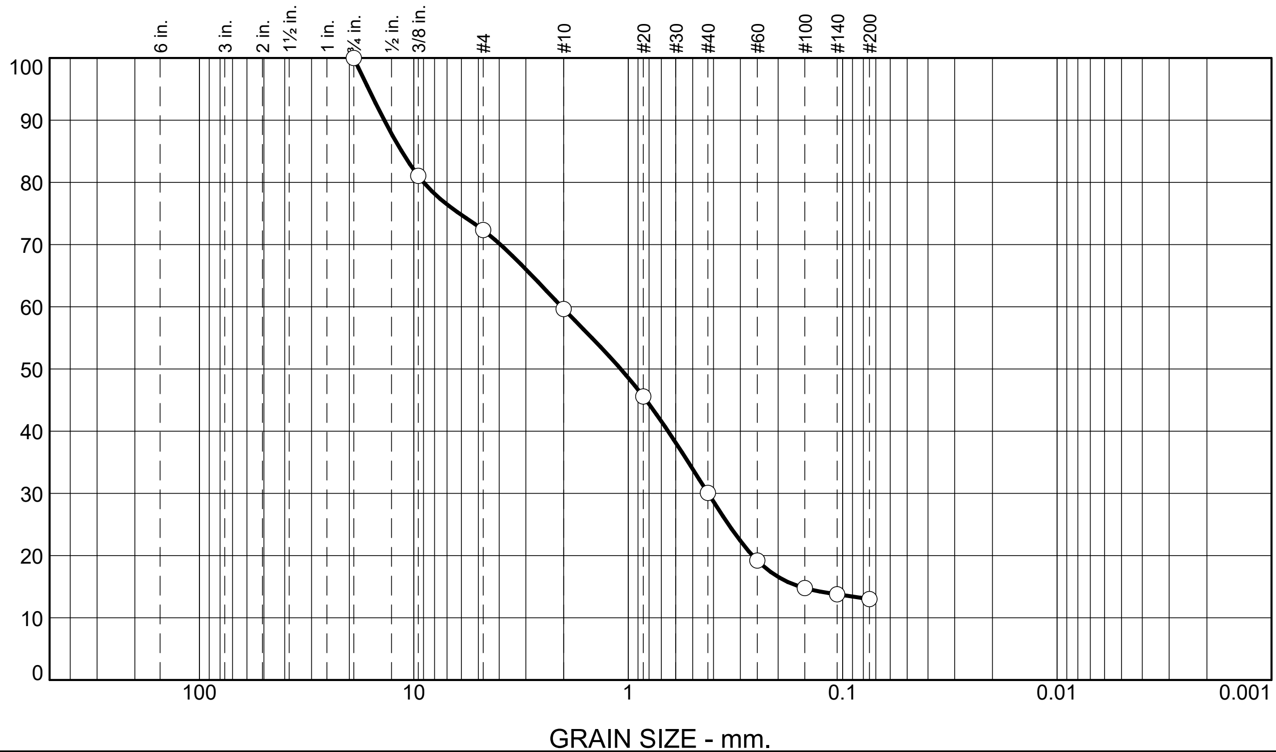
Bottom of borehole at 37 feet

APPENDIX B

LABORATORY REPORT

These results are for the exclusive use of the client for whom they were obtained. They apply only to the samples tested and are not indicitive of apparently identical samples.

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	27.7	12.6	29.6	17.1	13.0	

TEST RESULTS			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
.75	100.0		
.375	81.0		
#4	72.3		
#10	59.7		
#20	45.6		
#40	30.1		
#60	19.2		
#100	14.8		
#140	13.8		
#200	13.0		

* (no specification provided)

Material Description

silty sand with gravel

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 13.7242 D_{85}= 11.3908 D_{60}= 2.0451
D_{50}= 1.0837 D_{30}= 0.4237 D_{15}= 0.1579
D_{10}= C_u= C_c=

Remarks

Date Received: 2/24/2020 **Date Tested:**

Tested By: AH

Checked By: DH

Title: PE

Source of Sample: B-16-20 **Depth:** 8.6 **Date Sampled:**
Sample Number: SPT5

HILLIS-CARNES ENGINEERING ASSOCIATES

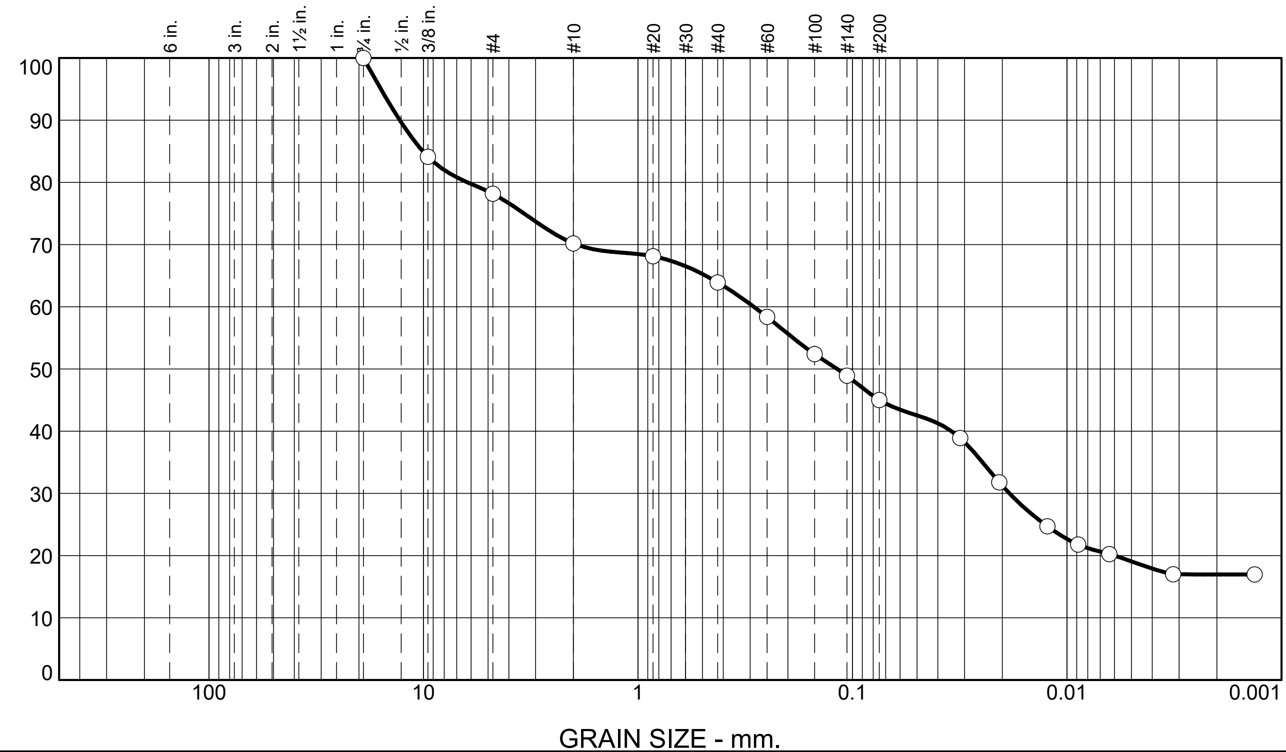
Philadelphia, Pennsylvania

Client: Geosyntec - Simone Smith
Project: Geosyntec-Delaware Valley Works

Project No: P20014 **Figure**

These results are for the exclusive use of the client for whom they were obtained. They apply only to the samples tested and are not indicitive of apparently identical samples.

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	21.8	8.0	6.3	18.9	25.9	19.1

TEST RESULTS			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
.75	100.0		
.375	84.1		
#4	78.2		
#10	70.2		
#20	68.1		
#40	63.9		
#60	58.4		
#100	52.4		
#140	48.9		
#200	45.0		
0.0315 mm.	38.9		
0.0207 mm.	31.8		
0.0123 mm.	24.7		
0.0089 mm.	21.8		
0.0063 mm.	20.2		
0.0032 mm.	17.0		
0.0013 mm.	16.9		

* (no specification provided)

Material Description

silty sand with gravel

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** 21 **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-4(0)

Coefficients

D_{90}= 12.8928 D_{85}= 10.0621 D_{60}= 0.2879
D_{50}= 0.1177 D_{30}= 0.0186 D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 2/24/2020 **Date Tested:**

Tested By: AH

Checked By: DH

Title:

Source of Sample: B-16-20 **Depth:** 25.2 **Date Sampled:**
Sample Number: SPT7

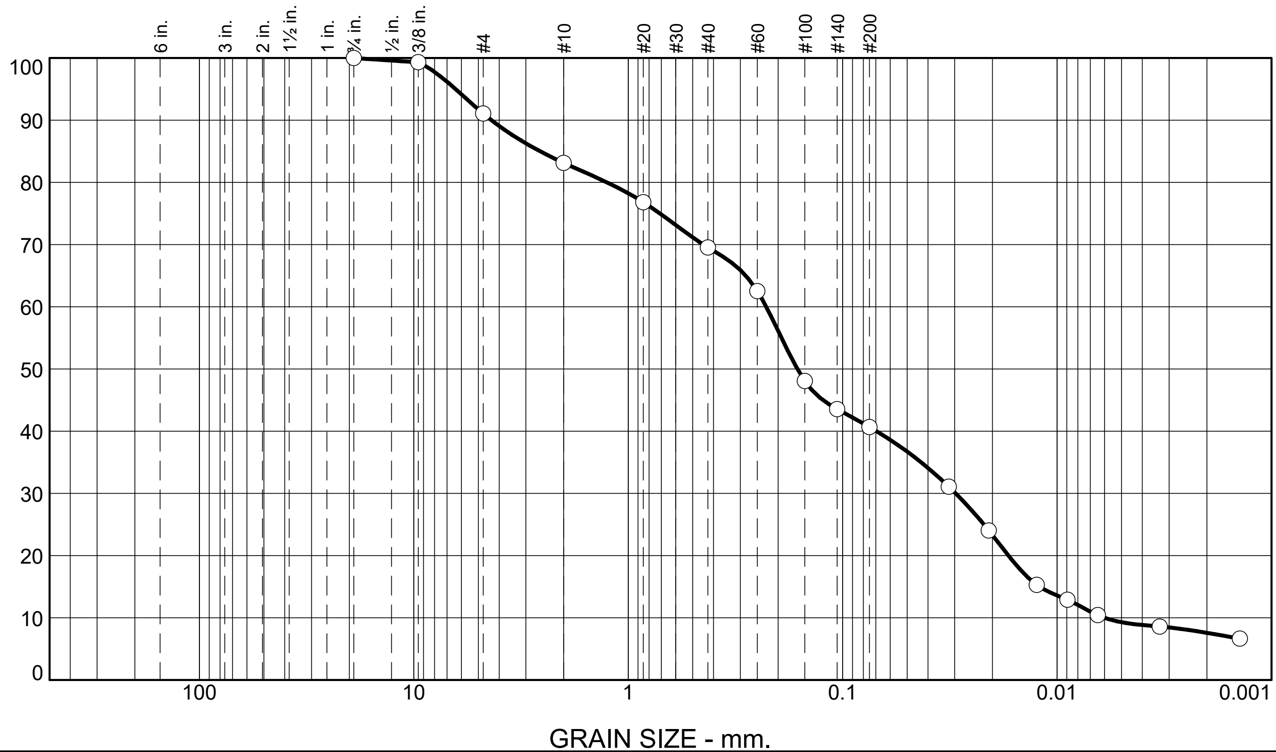
HILLIS-CARNES ENGINEERING ASSOCIATES

Philadelphia, Pennsylvania

Client: Geosyntec - Simone Smith
Project: Geosyntec-Delaware Valley Works
Project No: P20014 **Figure**

These results are for the exclusive use of the client for whom they were obtained. They apply only to the samples tested and are not indicitive of apparently identical samples.

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	8.9	8.0	13.6	28.8	31.4	9.3

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
.75	100.0		
.375	99.3		
#4	91.1		
#10	83.1		
#20	76.8		
#40	69.5		
#60	62.5		
#100	48.1		
#140	43.6		
#200	40.7		
0.0320 mm.	31.1		
0.0208 mm.	24.0		
0.0124 mm.	15.3		
0.0089 mm.	12.9		
0.0065 mm.	10.4		
0.0033 mm.	8.6		
0.0014 mm.	6.6		

* (no specification provided)

Material Description

silty sand

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** 25 **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-4(0)

Coefficients

D_{90}= 4.3398 D_{85}= 2.5721 D_{60}= 0.2271
D_{50}= 0.1626 D_{30}= 0.0297 D_{15}= 0.0121
D_{10}= 0.0060 C_u= 37.79 C_c= 0.65

Remarks

Date Received: ________ **Date Tested:** ________

Tested By: ________

Checked By: ________

Title: ________

Source of Sample: B-16-20 **Depth:** 20.5 **Date Sampled:**
Sample Number: ST-1

HILLIS-CARNES ENGINEERING ASSOCIATES

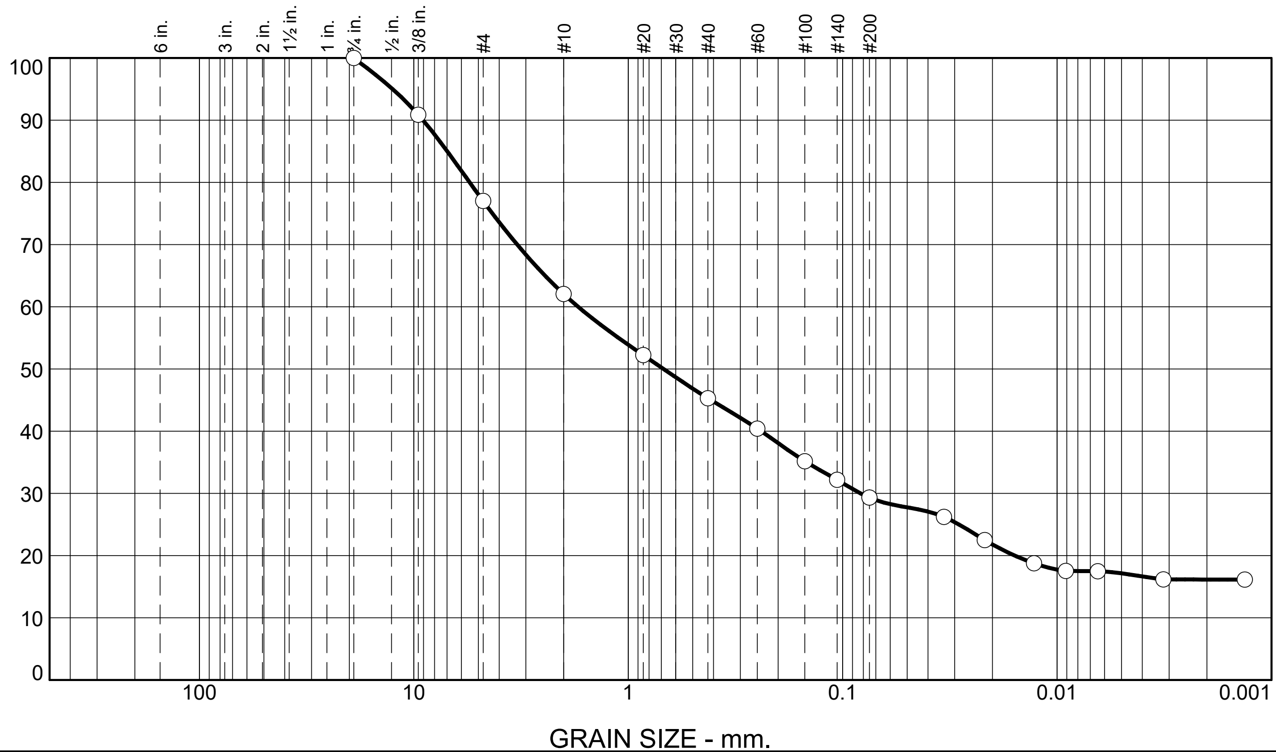
Philadelphia, Pennsylvania

Client: Geosyntec - Simone Smith
Project: Geosyntec-Delaware Valley Works

Project No: P20014 **Figure**

These results are for the exclusive use of the client for whom they were obtained. They apply only to the samples tested and are not indicitive of apparently identical samples.

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	23.0	14.9	16.8	16.0	12.2	17.1

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
.75	100.0		
.375	90.9		
#4	77.0		
#10	62.1		
#20	52.2		
#40	45.3		
#60	40.4		
#100	35.2		
#140	32.2		
#200	29.3		
0.0337 mm.	26.2		
0.0217 mm.	22.5		
0.0128 mm.	18.8		
0.0091 mm.	17.5		
0.0065 mm.	17.5		
0.0032 mm.	16.2		
0.0013 mm.	16.1		

* (no specification provided)

Material Description

silty sand with gravel

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** 35 **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-2-4(0)

Coefficients

D_{90}= 9.0568 D_{85}= 6.9803 D_{60}= 1.7134
D_{50}= 0.6848 D_{30}= 0.0825 D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 2/24/2020 **Date Tested:**

Tested By: AH

Checked By: DH

Title: PE

Source of Sample: B-17-20 **Depth:** 8 **Date Sampled:**
Sample Number: SPT5

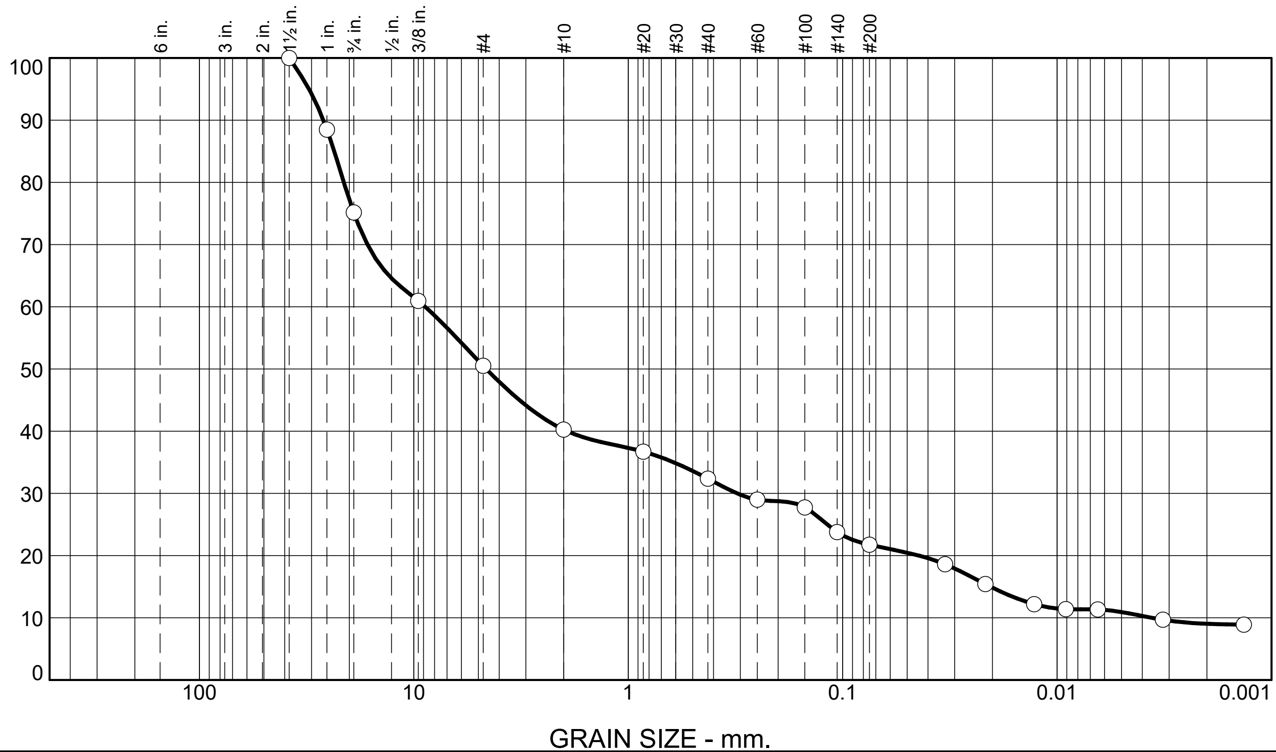
HILLIS-CARNES ENGINEERING ASSOCIATES

Philadelphia, Pennsylvania

Client: Geosyntec - Simone Smith
Project: Geosyntec-Delaware Valley Works

Project No: P20014 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	24.8	24.7	10.3	7.8	10.7	10.8	10.9

TEST RESULTS			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5	100.0		
1	88.5		
.75	75.2		
.375	61.0		
#4	50.5		
#10	40.2		
#20	36.7		
#40	32.4		
#60	29.0		
#100	27.7		
#140	23.8		
#200	21.7		
0.0333 mm.	18.6		
0.0216 mm.	15.4		
0.0128 mm.	12.2		
0.0091 mm.	11.4		
0.0065 mm.	11.3		
0.0032 mm.	9.7		
0.0013 mm.	8.9		

* (no specification provided)

Material Description

silty gravel with sand

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= GM **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 26.3802 D_{85}= 23.4951 D_{60}= 8.8457
D_{50}= 4.5911 D_{30}= 0.3107 D_{15}= 0.0205
D_{10}= 0.0036 C_u= 2438.88 C_c= 3.01

Remarks

Date Received: 2/24/2020 **Date Tested:**

Tested By: AH

Checked By: DH

Title: PE

Source of Sample: B-18-20 **Depth:** 4 **Date Sampled:**
Sample Number: SPT3

HILLIS-CARNES ENGINEERING ASSOCIATES

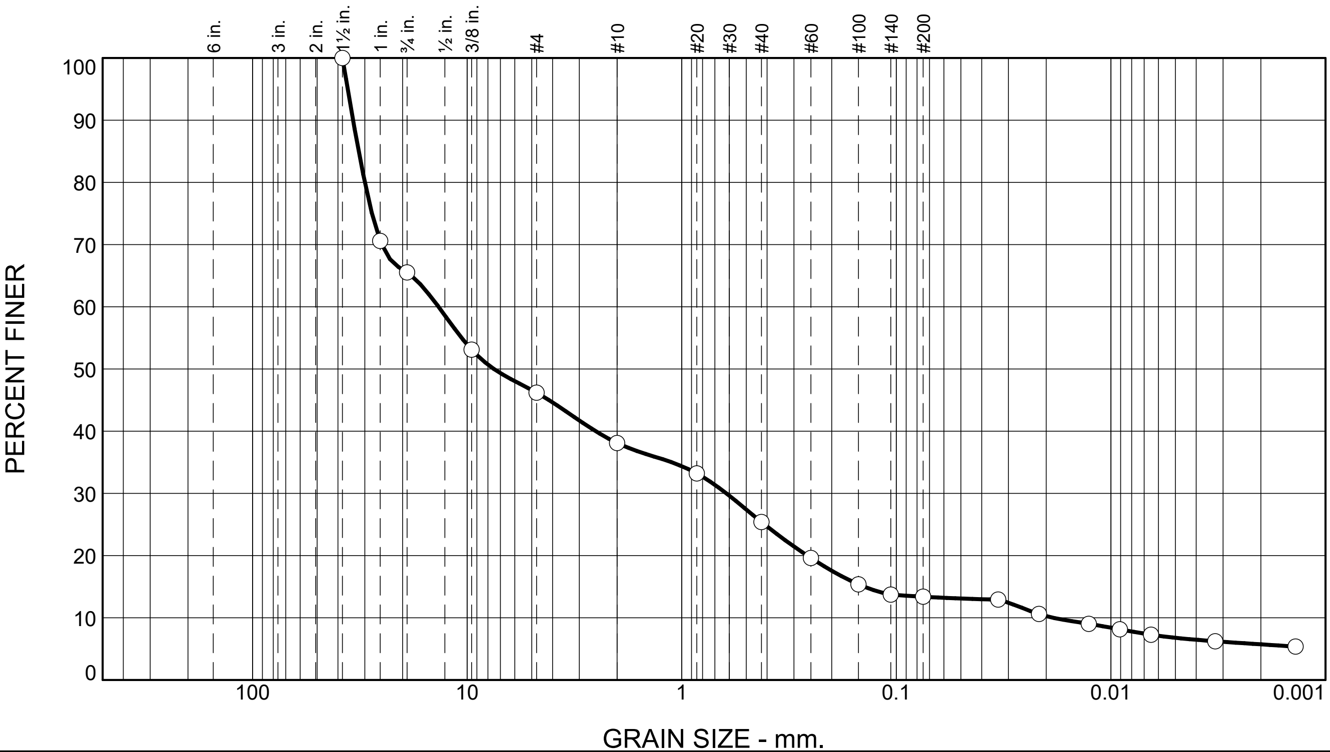
Philadelphia, Pennsylvania

Client: Geosyntec - Simone Smith
Project: Geosyntec-Delaware Valley Works

Project No: P20014 **Figure**

These results are for the exclusive use of the client for whom they were obtained. They apply only to the samples tested and are not indicitive of apparently identical samples.

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	34.5	19.3	8.1	12.7	12.0	6.6	6.8

TEST RESULTS			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5	100.0		
1	70.6		
.75	65.5		
.375	53.1		
#4	46.2		
#10	38.1		
#20	33.2		
#40	25.4		
#60	19.6		
#100	15.4		
#140	13.7		
#200	13.4		
0.0335 mm.	12.9		
0.0216 mm.	10.6		
0.0127 mm.	9.0		
0.0091 mm.	8.1		
0.0065 mm.	7.3		
0.0033 mm.	6.2		
0.0014 mm.	5.4		

* (no specification provided)

Material Description

silty gravel with sand

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** 35 **PI=** NP

Classification

USCS (D 2487)= GM **AASHTO (M 145)=** A-1-a

Coefficients

D_{90}= 34.0072 D_{85}= 32.0166 D_{60}= 13.5932
D_{50}= 7.4986 D_{30}= 0.6199 D_{15}= 0.1413
D_{10}= 0.0186 C_u= 731.03 C_c= 1.52

Remarks

Date Received: 2/24/2020 **Date Tested:**

Tested By: AH

Checked By: DH

Title: PE

Source of Sample: B-18-20 **Depth:** 24 **Date Sampled:**
Sample Number: ST-1

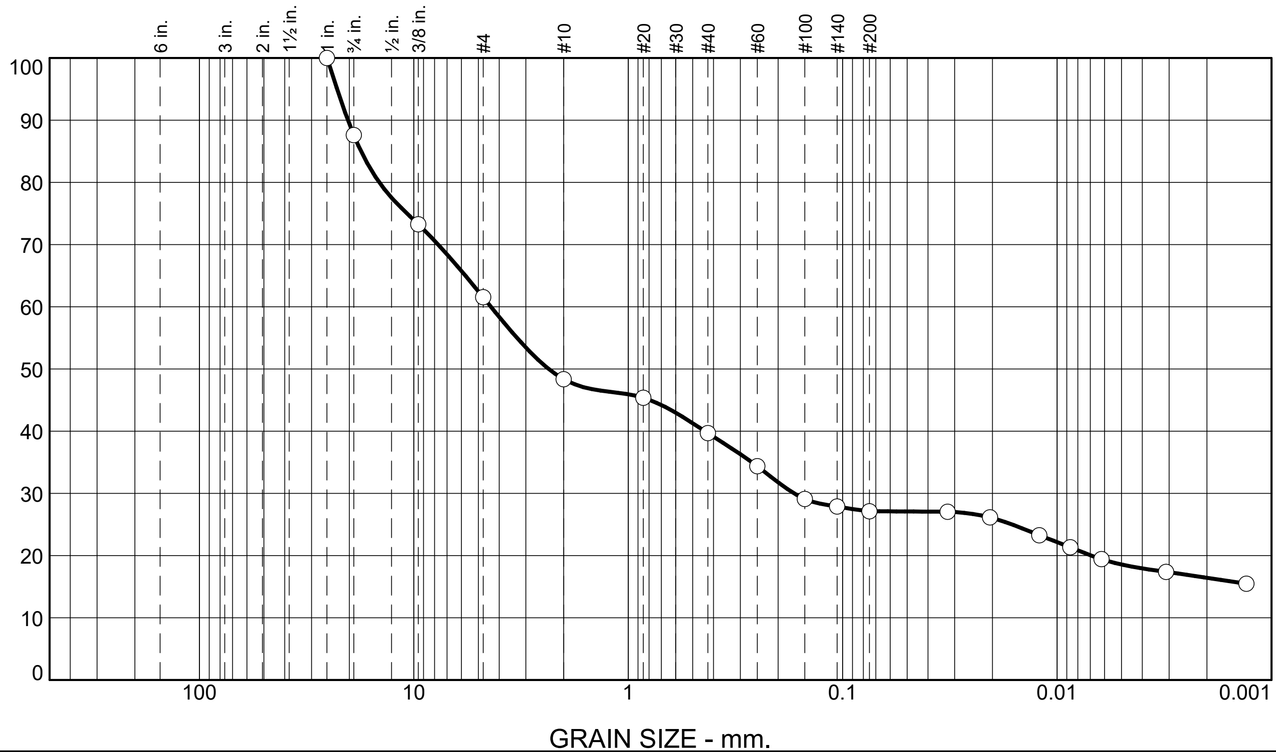
HILLIS-CARNES ENGINEERING ASSOCIATES

Philadelphia, Pennsylvania

Client: Geosyntec - Simone Smith
Project: Geosyntec-Delaware Valley Works

Project No: P20014 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	12.4	26.0	13.2	8.7	12.6	8.5	18.6

TEST RESULTS			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1	100.0		
.75	87.6		
.375	73.3		
#4	61.6		
#10	48.4		
#20	45.4		
#40	39.7		
#60	34.4		
#100	29.1		
#140	27.9		
#200	27.1		
0.0323 mm.	27.0		
0.0206 mm.	26.1		
0.0121 mm.	23.3		
0.0087 mm.	21.3		
0.0062 mm.	19.4		
0.0031 mm.	17.4		
0.0013 mm.	15.5		

* (no specification provided)

Material Description

clayey gravel with sand

Atterberg Limits (ASTM D 4318)

PL= 15 **LL=** 23 **PI=** 8

Classification

USCS (D 2487)= GC **AASHTO (M 145)=** A-2-4(0)

Coefficients

D_{90}= 20.2719 D_{85}= 17.6147 D_{60}= 4.3650
D_{50}= 2.3494 D_{30}= 0.1685 D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 2/24/2020 **Date Tested:**

Tested By: AH

Checked By: DH

Title: PE

Source of Sample: B-19-20 **Depth:** 35.3 **Date Sampled:**
Sample Number: 10

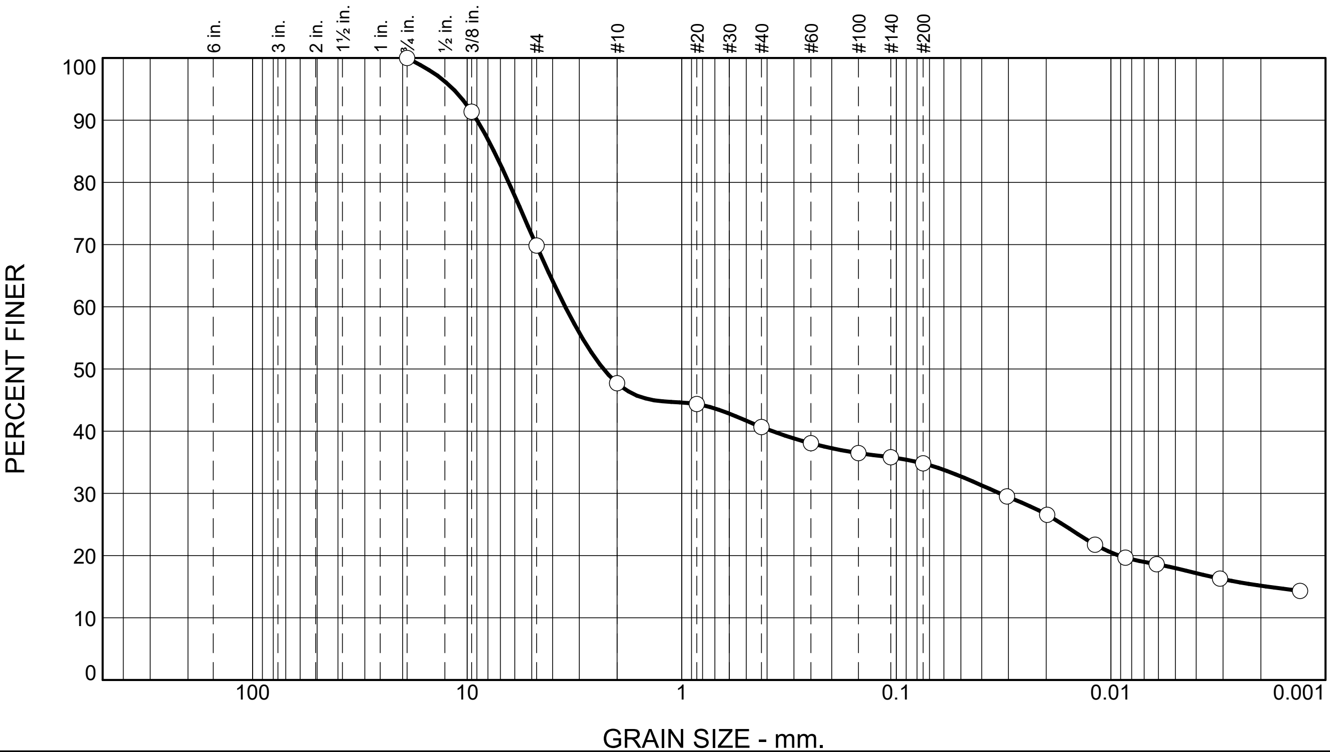
HILLIS-CARNES ENGINEERING ASSOCIATES

Philadelphia, Pennsylvania

Client: Geosyntec - Simone Smith
Project: Geosyntec-Delaware Valley Works

Project No: P20014 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	30.2	22.1	7.0	5.9	16.8	18.0

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
.75	100.0		
.375	91.4		
#4	69.8		
#10	47.7		
#20	44.4		
#40	40.7		
#60	38.1		
#100	36.5		
#140	35.8		
#200	34.8		
0.0305 mm.	29.5		
0.0198 mm.	26.5		
0.0118 mm.	21.7		
0.0086 mm.	19.7		
0.0061 mm.	18.6		
0.0031 mm.	16.3		
0.0013 mm.	14.3		

* (no specification provided)

Material Description

clayey sand with gravel

Atterberg Limits (ASTM D 4318)

PL= 16 **LL=** 26 **PI=** 10

Classification

USCS (D 2487)= SC **AASHTO (M 145)=** A-2-4(0)

Coefficients

D_{90}= 8.9860 D_{85}= 7.4943 D_{60}= 3.4881
D_{50}= 2.3145 D_{30}= 0.0329 D_{15}= 0.0019
D_{10}= C_u= C_c=

Remarks

Date Received: 2/24/2020 **Date Tested:**

Tested By: AH

Checked By: DH

Title: PE

Source of Sample: B-20-20 **Depth:** 35.5 **Date Sampled:**
Sample Number: 10

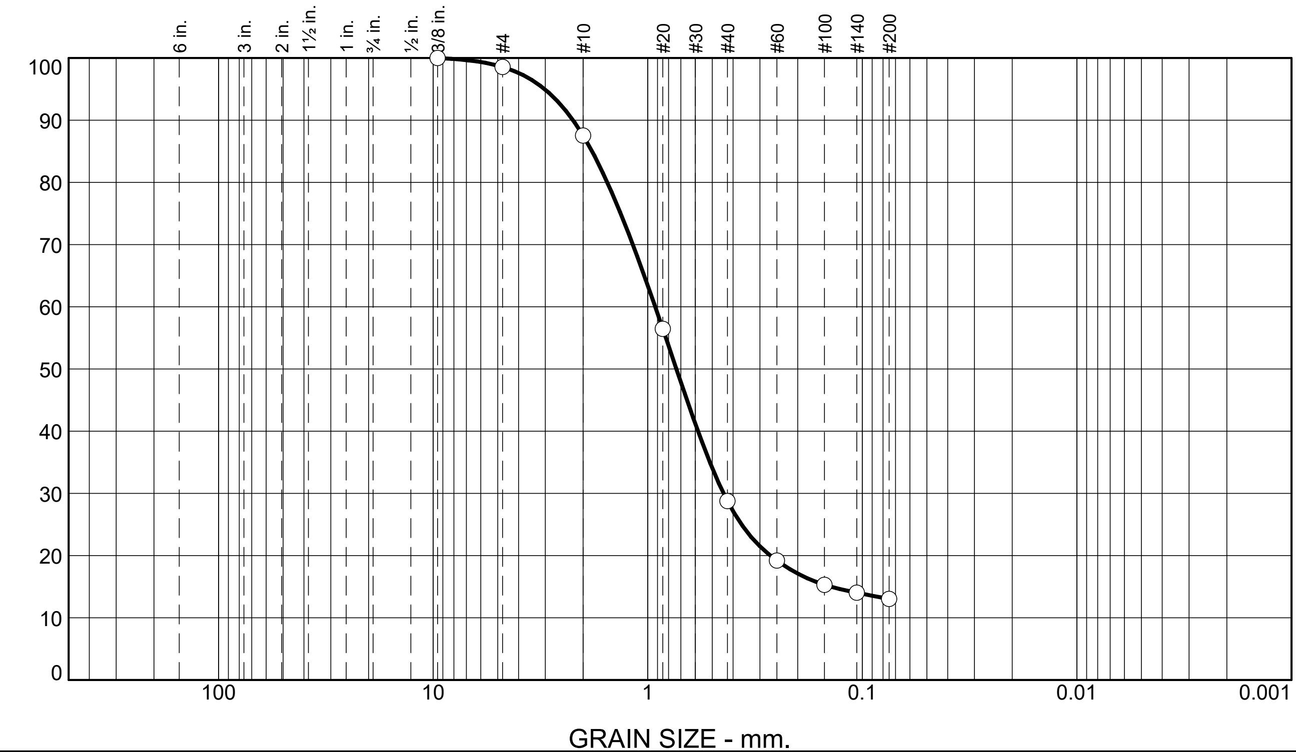
HILLIS-CARNES ENGINEERING ASSOCIATES

Philadelphia, Pennsylvania

Client: Geosyntec - Simone Smith
Project: Geosyntec-Delaware Valley Works

Project No: P20014 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	1.4	11.1	58.7	15.8	13.0	

TEST RESULTS			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
.375	100.0		
#4	98.6		
#10	87.5		
#20	56.4		
#40	28.8		
#60	19.2		
#100	15.3		
#140	14.0		
#200	13.0		

* (no specification provided)

Material Description

silty sand

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 2.2278 D_{85}= 1.8168 D_{60}= 0.9222
D_{50}= 0.7351 D_{30}= 0.4431 D_{15}= 0.1407
D_{10}= C_u= C_c=

Remarks

Date Received: 2/24/2020 **Date Tested:**
Tested By: AH
Checked By: DH
Title: PE

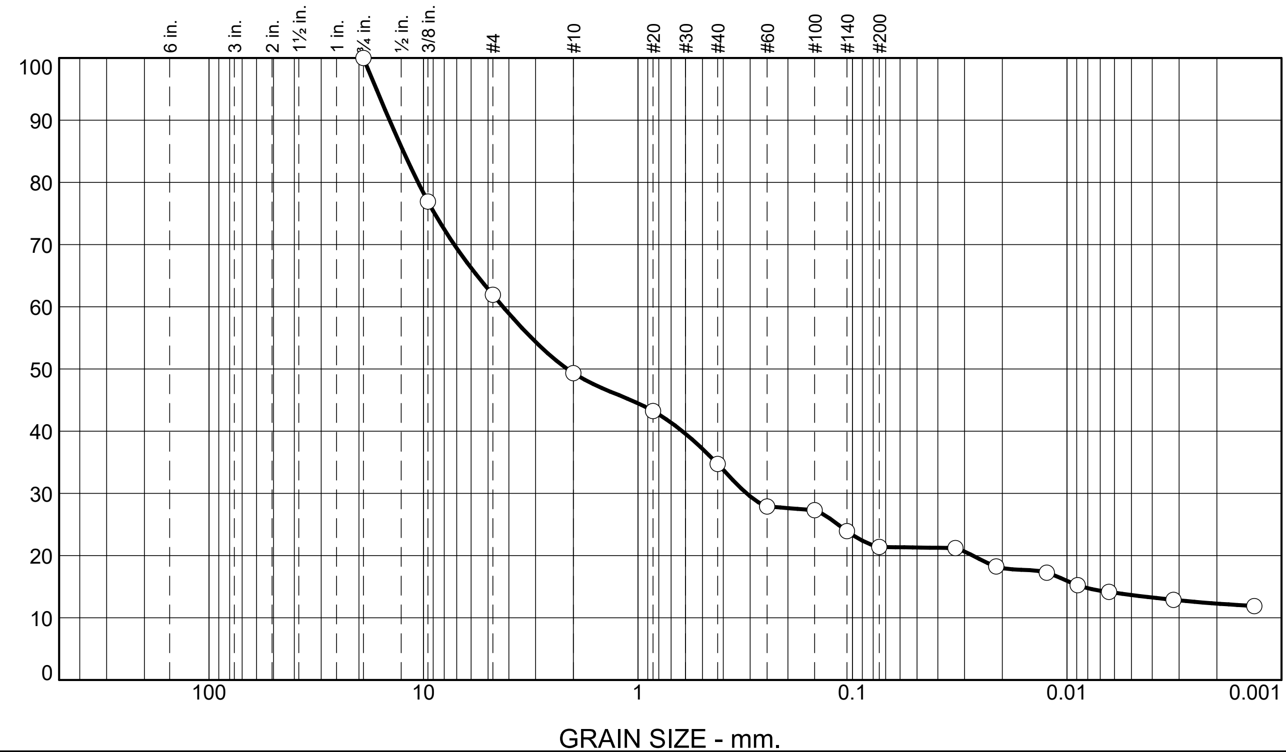
Source of Sample: B-20-20 **Depth:** 50 **Date Sampled:**
Sample Number: 13

HILLIS-CARNES ENGINEERING ASSOCIATES
Philadelphia, Pennsylvania

Client: Geosyntec - Simone Smith
Project: Geosyntec-Delaware Valley Works
Project No: P20014 **Figure**

These results are for the exclusive use of the client for whom they were obtained. They apply only to the samples tested and are not indicitive of apparently identical samples.

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	38.1	12.6	14.6	13.3	7.7	13.7

TEST RESULTS			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
.75	100.0		
.375	76.9		
#4	61.9		
#10	49.3		
#20	43.2		
#40	34.7		
#60	27.9		
#100	27.3		
#140	23.9		
#200	21.4		
0.0331 mm.	21.2		
0.0213 mm.	18.2		
0.0124 mm.	17.2		
0.0089 mm.	15.2		
0.0064 mm.	14.1		
0.0032 mm.	12.9		
0.0013 mm.	11.9		

* (no specification provided)

Material Description

silty sand with gravel

Atterberg Limits (ASTM D 4318)

PL= 25 **LL=** 25 **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 14.3913 D_{85}= 12.4165 D_{60}= 4.2557
D_{50}= 2.1346 D_{30}= 0.3117 D_{15}= 0.0085
D_{10}= C_u= C_c=

Remarks

Date Received: 2/24/2020 **Date Tested:**

Tested By: AH

Checked By: DH

Title: PE

Source of Sample: B-21-20 **Depth:** 2 **Date Sampled:**
Sample Number: SPT2

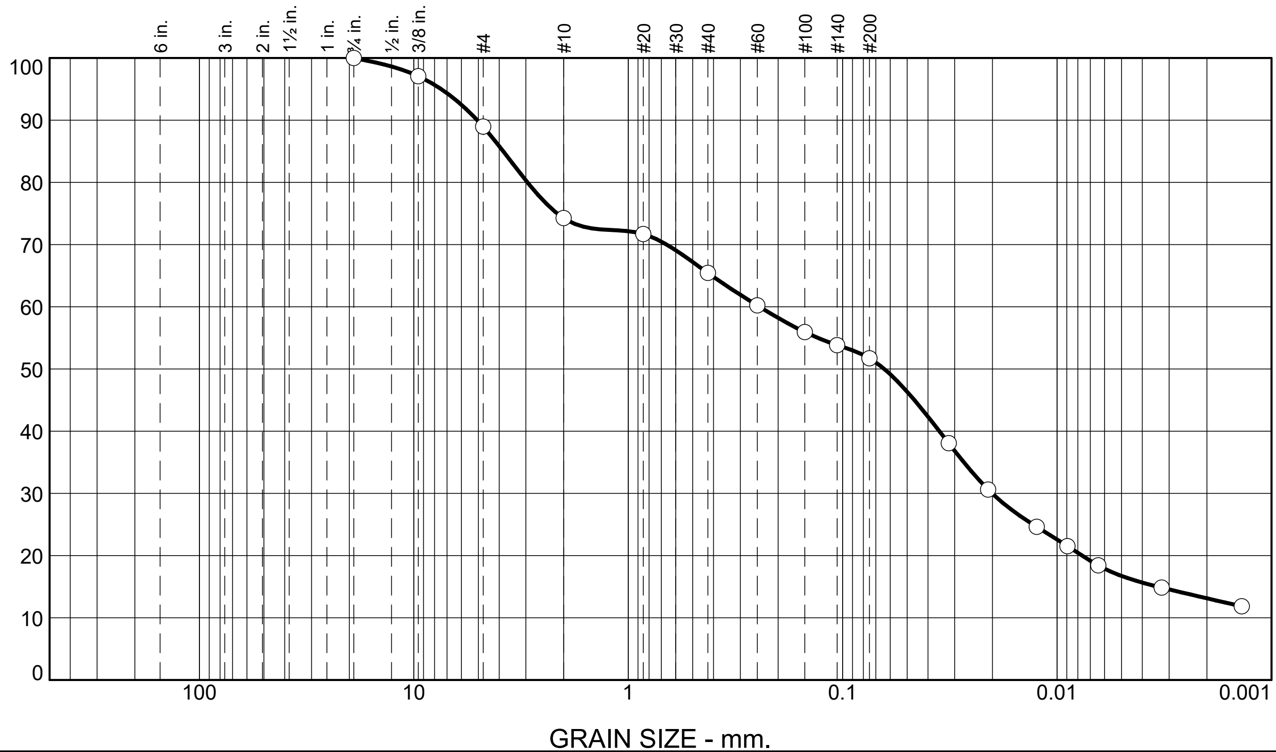
HILLIS-CARNES ENGINEERING ASSOCIATES

Philadelphia, Pennsylvania

Client: Geosyntec - Simone Smith
Project: Geosyntec-Delaware Valley Works

Project No: P20014 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	11.0	14.7	8.9	13.7	35.0	16.7

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
.75	100.0		
.375	97.1		
#4	89.0		
#10	74.3		
#20	71.7		
#40	65.4		
#60	60.2		
#100	55.9		
#140	53.8		
#200	51.7		
0.0320 mm.	38.1		
0.0210 mm.	30.6		
0.0124 mm.	24.6		
0.0089 mm.	21.5		
0.0064 mm.	18.4		
0.0033 mm.	14.9		
0.0014 mm.	11.8		

* (no specification provided)

Material Description

sandy silty clay

Atterberg Limits (ASTM D 4318)

PL= 22 **LL=** 28 **PI=** 6

Classification

USCS (D 2487)= CL-ML **AASHTO (M 145)=** A-4(1)

Coefficients

D_{90}= 5.0531 D_{85}= 3.8248 D_{60}= 0.2439
D_{50}= 0.0639 D_{30}= 0.0201 D_{15}= 0.0034
D_{10}= C_u= C_c=

Remarks

Date Received: ________ **Date Tested:** ________

Tested By: ________

Checked By: ________

Title: ________

Source of Sample: B-22-20 **Depth:** 18 **Date Sampled:**
Sample Number: ST-1

HILLIS-CARNES ENGINEERING ASSOCIATES

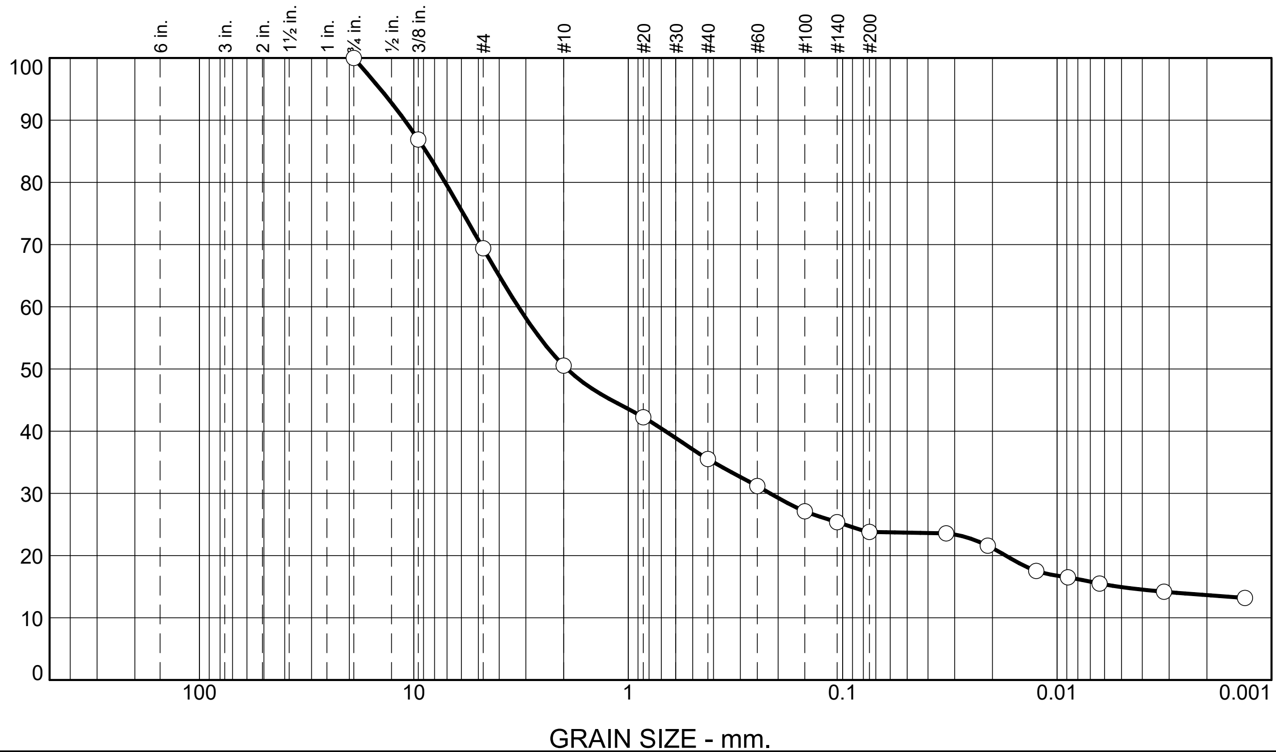
Philadelphia, Pennsylvania

Client: Geosyntec - Simone Smith
Project: Geosyntec-Delaware Valley Works

Project No: P20014 **Figure**

These results are for the exclusive use of the client for whom they were obtained. They apply only to the samples tested and are not indicitive of apparently identical samples.

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	30.6	18.9	15.0	11.7	8.9	14.9

TEST RESULTS			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
.75	100.0		
.375	86.9		
#4	69.4		
#10	50.5		
#20	42.2		
#40	35.5		
#60	31.2		
#100	27.1		
#140	25.4		
#200	23.8		
0.0329 mm.	23.6		
0.0211 mm.	21.6		
0.0125 mm.	17.5		
0.0089 mm.	16.5		
0.0063 mm.	15.5		
0.0032 mm.	14.2		
0.0013 mm.	13.2		

* (no specification provided)

Material Description

silty sand with gravel

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** 32 **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 11.0203 D_{85}= 8.7615 D_{60}= 3.2523
D_{50}= 1.9284 D_{30}= 0.2179 D_{15}= 0.0052
D_{10}= C_u= C_c=

Remarks

Date Received: 2/24/2020 **Date Tested:**

Tested By: AH

Checked By: DH

Title: PE

Source of Sample: B-24-20 **Depth:** 6.3 **Date Sampled:**
Sample Number: SPT4

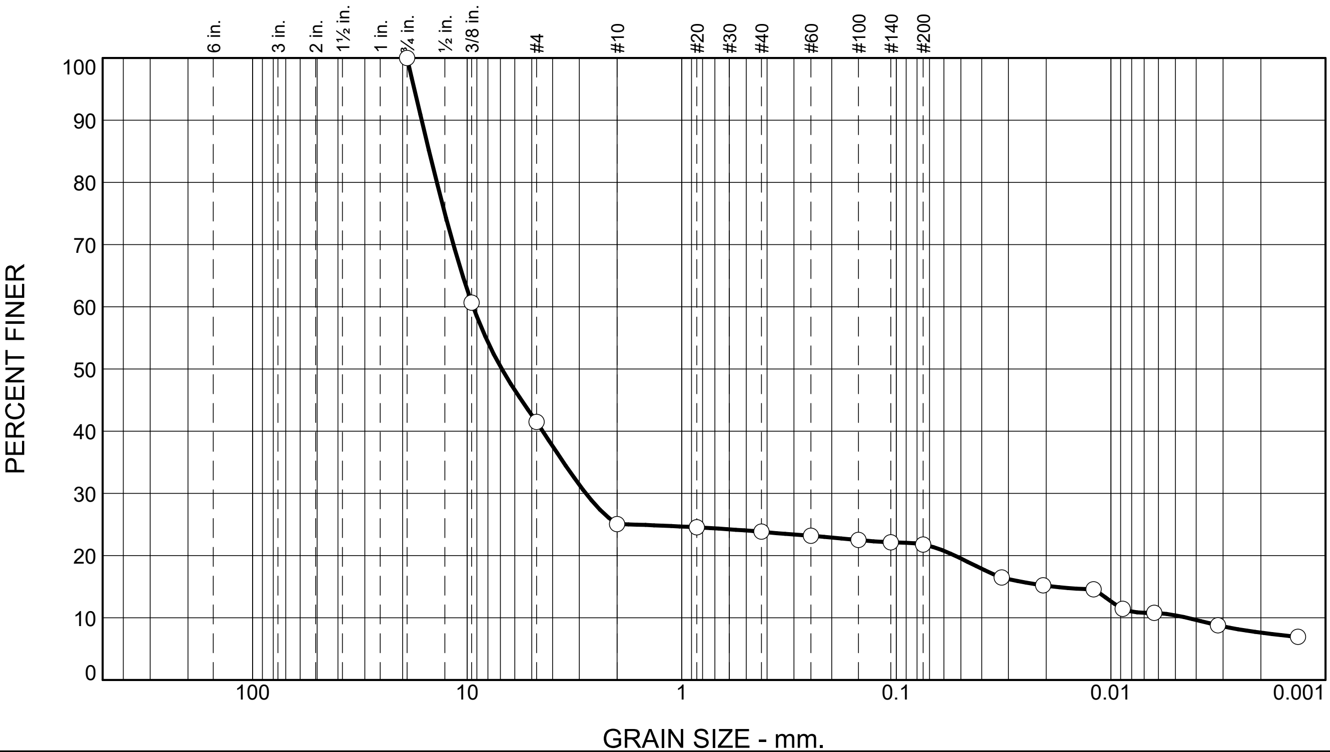
HILLIS-CARNES ENGINEERING ASSOCIATES

Philadelphia, Pennsylvania

Client: Geosyntec - Simone Smith
Project: Geosyntec-Delaware Valley Works

Project No: P20014 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	58.5	16.4	1.3	2.0	11.4	10.4

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
.75	100.0		
.375	60.7		
#4	41.5		
#10	25.1		
#20	24.5		
#40	23.8		
#60	23.2		
#100	22.5		
#140	22.1		
#200	21.8		
0.0322 mm.	16.5		
0.0207 mm.	15.2		
0.0120 mm.	14.6		
0.0088 mm.	11.4		
0.0063 mm.	10.8		
0.0032 mm.	8.8		
0.0013 mm.	6.9		

* (no specification provided)

Material Description

silty gravel with sand

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= GM **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 16.2883 D_{85}= 15.0340 D_{60}= 9.3689
D_{50}= 6.8943 D_{30}= 2.7976 D_{15}= 0.0184
D_{10}= 0.0044 C_u= 2114.56 C_c= 188.54

Remarks

Date Received: 2/24/2020 **Date Tested:**

Tested By: AH

Checked By: DH

Title: PE

Source of Sample: B-24-20 **Depth:** 31 **Date Sampled:**
Sample Number: SPT9

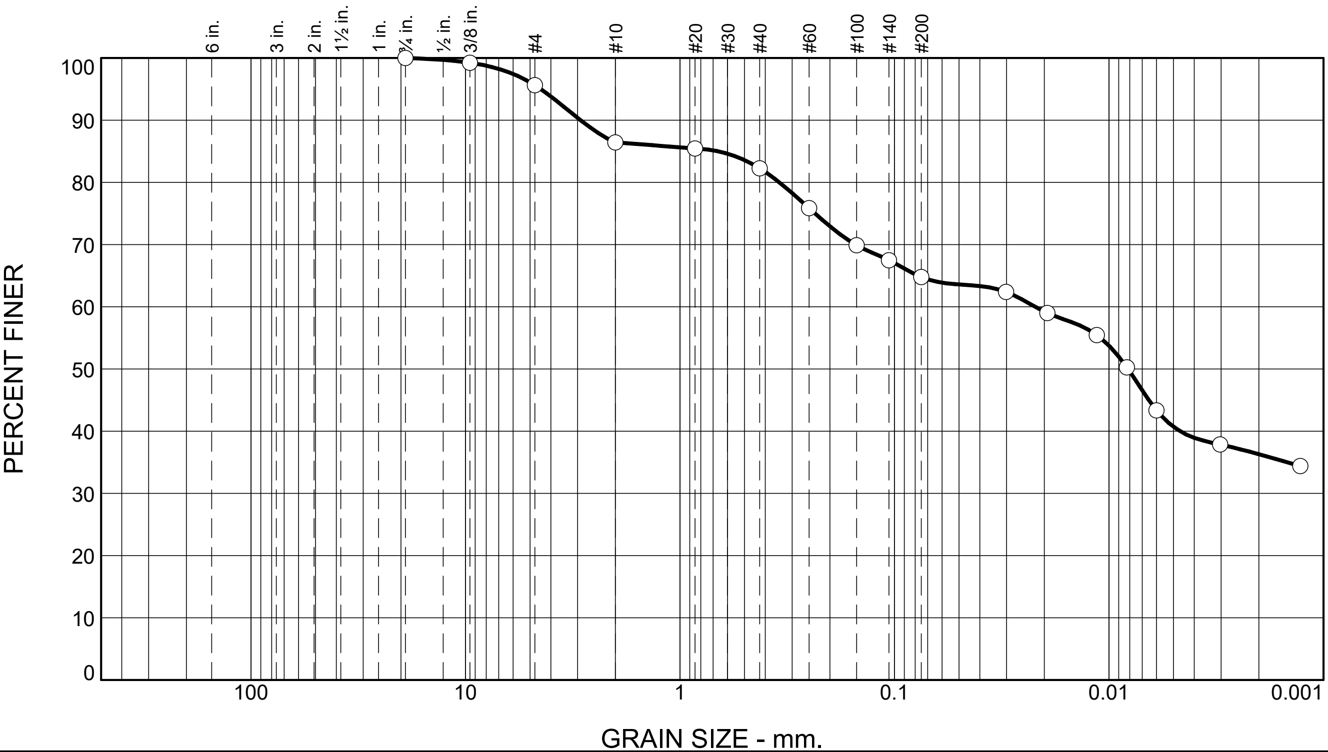
HILLIS-CARNES ENGINEERING ASSOCIATES

Philadelphia, Pennsylvania

Client: Geosyntec - Simone Smith
Project: Geosyntec-Delaware Valley Works

Project No: P20014 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	4.4	9.2	4.1	17.5	24.1	40.7

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
.75	100.0		
.375	99.2		
#4	95.6		
#10	86.4		
#20	85.5		
#40	82.3		
#60	75.9		
#100	69.9		
#140	67.5		
#200	64.8		
0.0302 mm.	62.4		
0.0194 mm.	59.0		
0.0114 mm.	55.4		
0.0082 mm.	50.3		
0.0060 mm.	43.3		
0.0030 mm.	37.9		
0.0013 mm.	34.4		

* (no specification provided)

Material Description

sandy silty clay

Atterberg Limits (ASTM D 4318)

PL= 17 **LL=** 21 **PI=** 4

Classification

USCS (D 2487)= CL-ML **AASHTO (M 145)=** A-4(0)

Coefficients

D_{90}= 2.9032 D_{85}= 0.6637 D_{60}= 0.0221
D_{50}= 0.0081 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: ____________ **Date Tested:** ____________

Tested By: ____________

Checked By: ____________

Title: ____________

Source of Sample: B-24-20 **Depth:** 13 **Date Sampled:**
Sample Number: ST-1

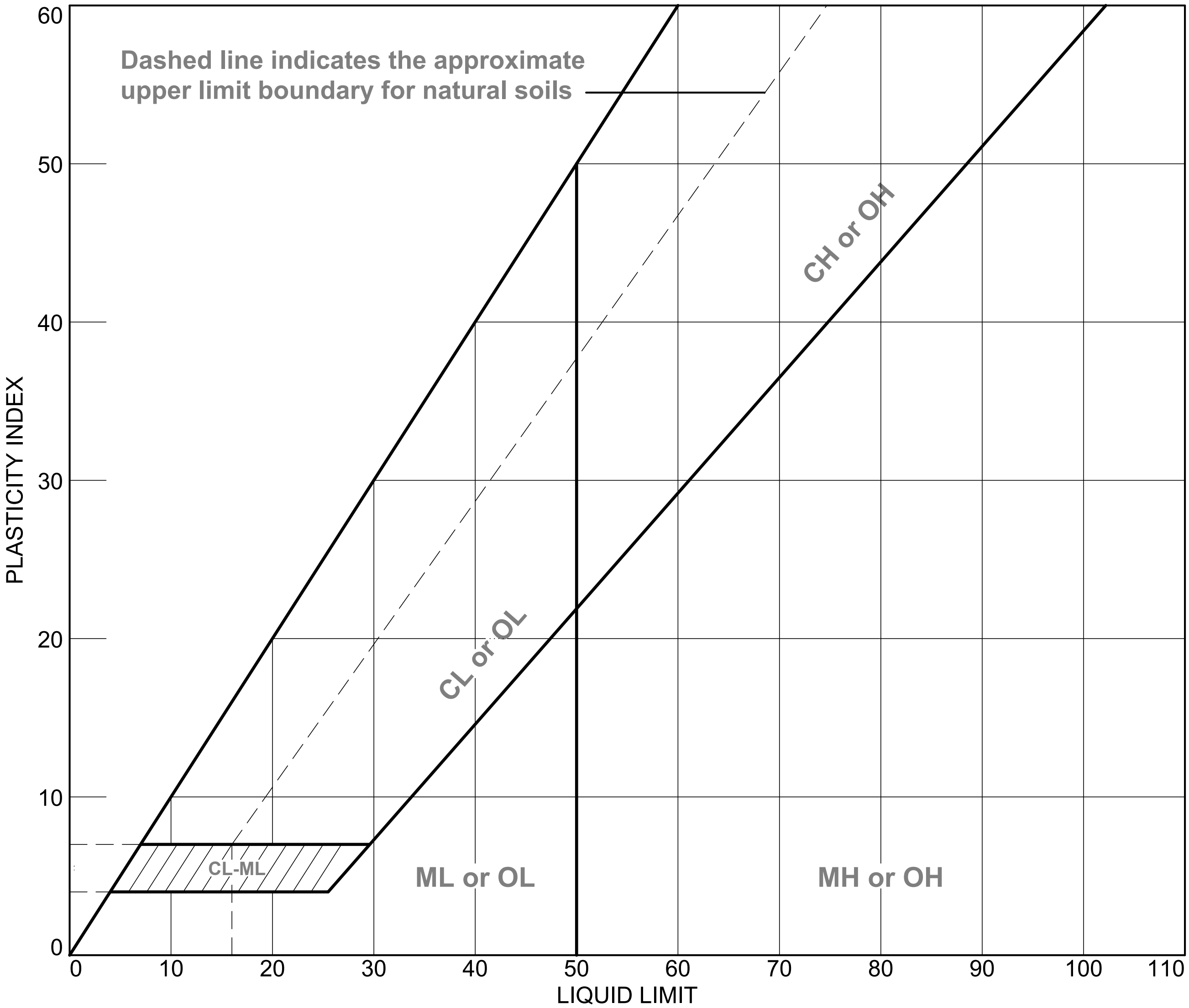
HILLIS-CARNES ENGINEERING ASSOCIATES

Philadelphia, Pennsylvania

Client: Geosyntec - Simone Smith
Project: Geosyntec-Delaware Valley Works

Project No: P20014 **Figure**

LIQUID AND PLASTIC LIMITS TEST REPORT

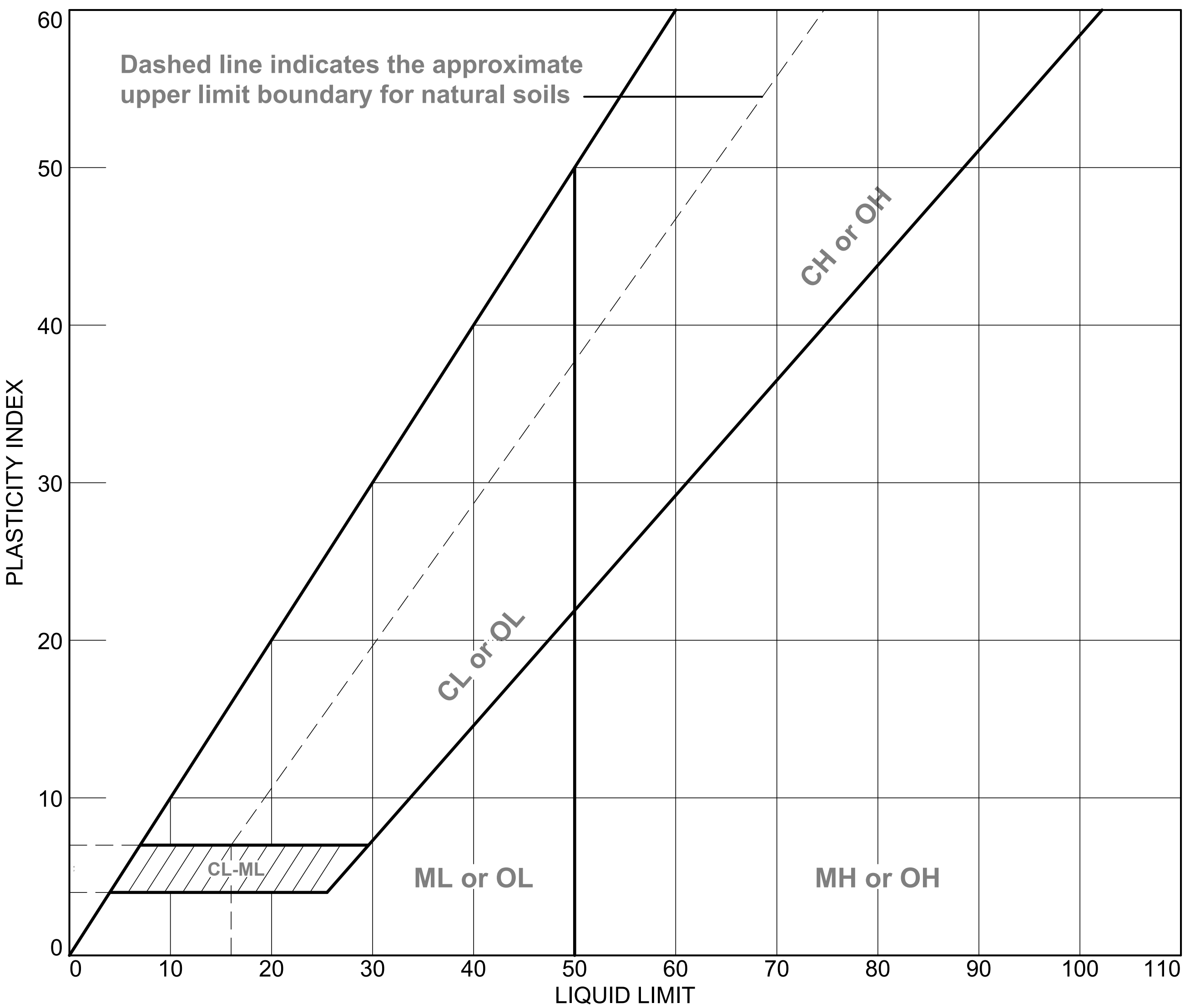


SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	B-16-20	SPT5	8.6	26.3	NP	NV	NP	SM
■	B-16-20	SPT7	25.2	17.6	NP	21	NP	SM
▲	B-16-20	ST-1	20.5	38.3	NP	25	NP	SM

HILLIS-CARNES ENGINEERING ASSOCIATES **Philadelphia, Pennsylvania**	**Client:** Geosyntec - Simone Smith **Project:** Geosyntec-Delaware Valley Works **Project No.:** P20014 **Figure**

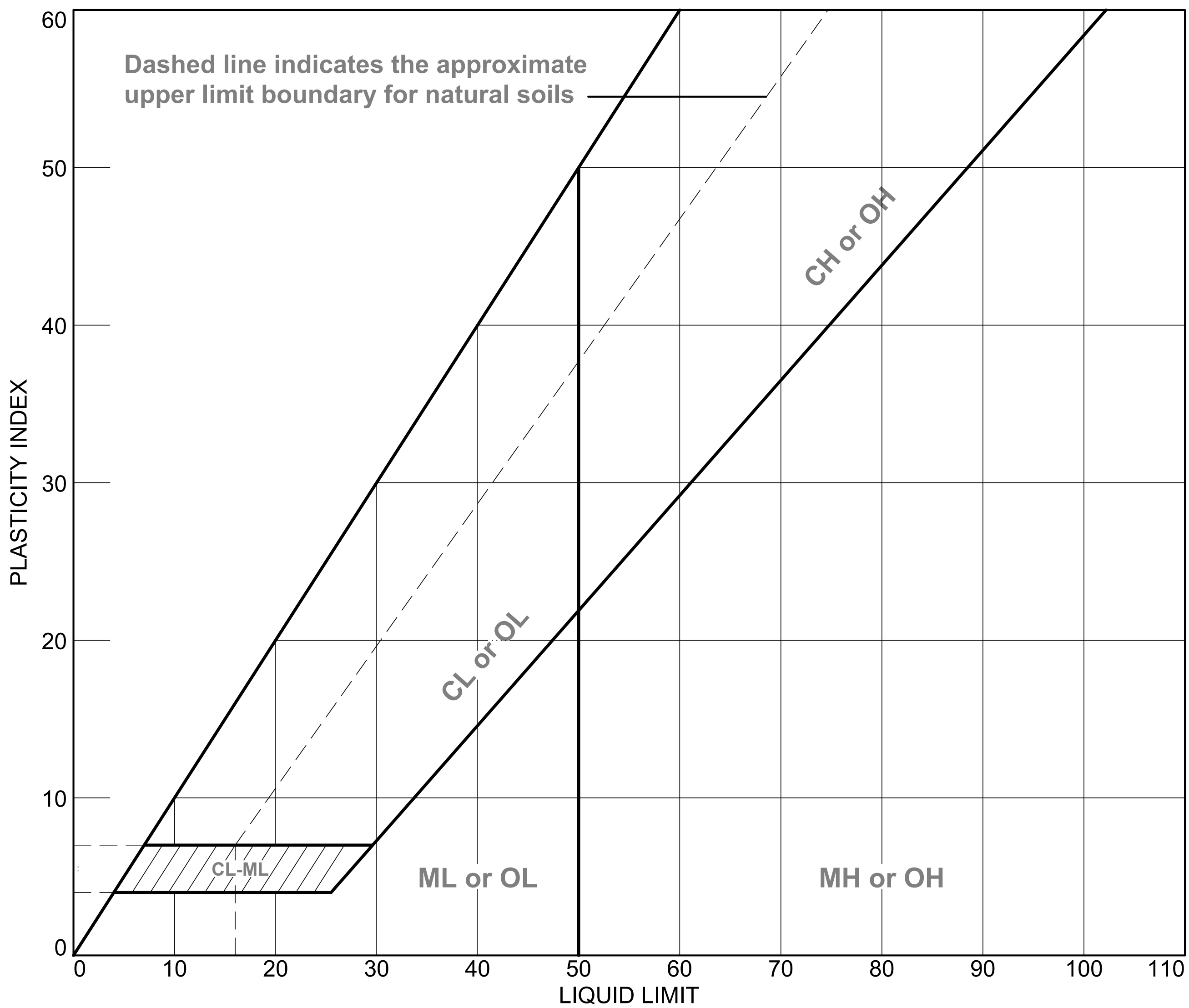
LIQUID AND PLASTIC LIMITS TEST REPORT



SOIL DATA								
SYMBOL	**SOURCE**	**SAMPLE NO.**	**DEPTH**	**NATURAL WATER CONTENT (%)**	**PLASTIC LIMIT (%)**	**LIQUID LIMIT (%)**	**PLASTICITY INDEX (%)**	**USCS**
●	B-17-20	SPT8	31	71.8				
■	B-17-20	SPT5	8	29.4	NP	35	NP	SM
▲	B-17-20	ST-1	20.5	37.4	NP	29	NP	

HILLIS-CARNES ENGINEERING ASSOCIATES **Philadelphia, Pennsylvania**	**Client:** Geosyntec - Simone Smith **Project:** Geosyntec-Delaware Valley Works **Project No.:** P20014 **Figure**

LIQUID AND PLASTIC LIMITS TEST REPORT



SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	B-18-20	ST-1	24	28.4	NP	35	NP	GM
■	B-18-20	SPT3	4	16.1	NP	NV	NP	GM

HILLIS-CARNES ENGINEERING ASSOCIATES

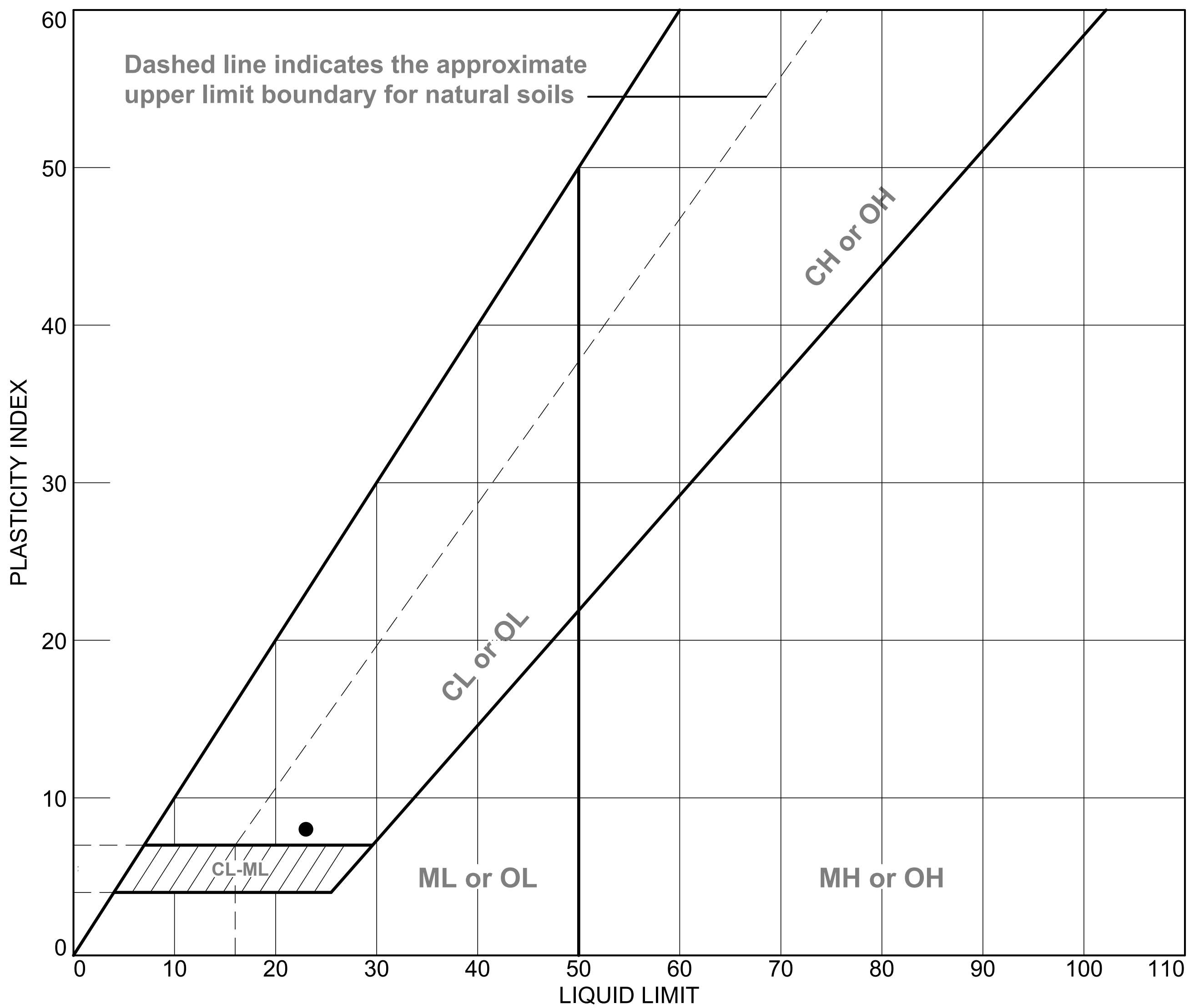
Philadelphia, Pennsylvania

Client: Geosyntec - Simone Smith

Project: Geosyntec-Delaware Valley Works

Project No.: P20014 **Figure**

LIQUID AND PLASTIC LIMITS TEST REPORT



SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	B-19-20	10	35.3	19.2	15	23	8	GC
■	B-19-20	ST-1	18	38.6	NP	NV	NP	

HILLIS-CARNES ENGINEERING ASSOCIATES

Philadelphia, Pennsylvania

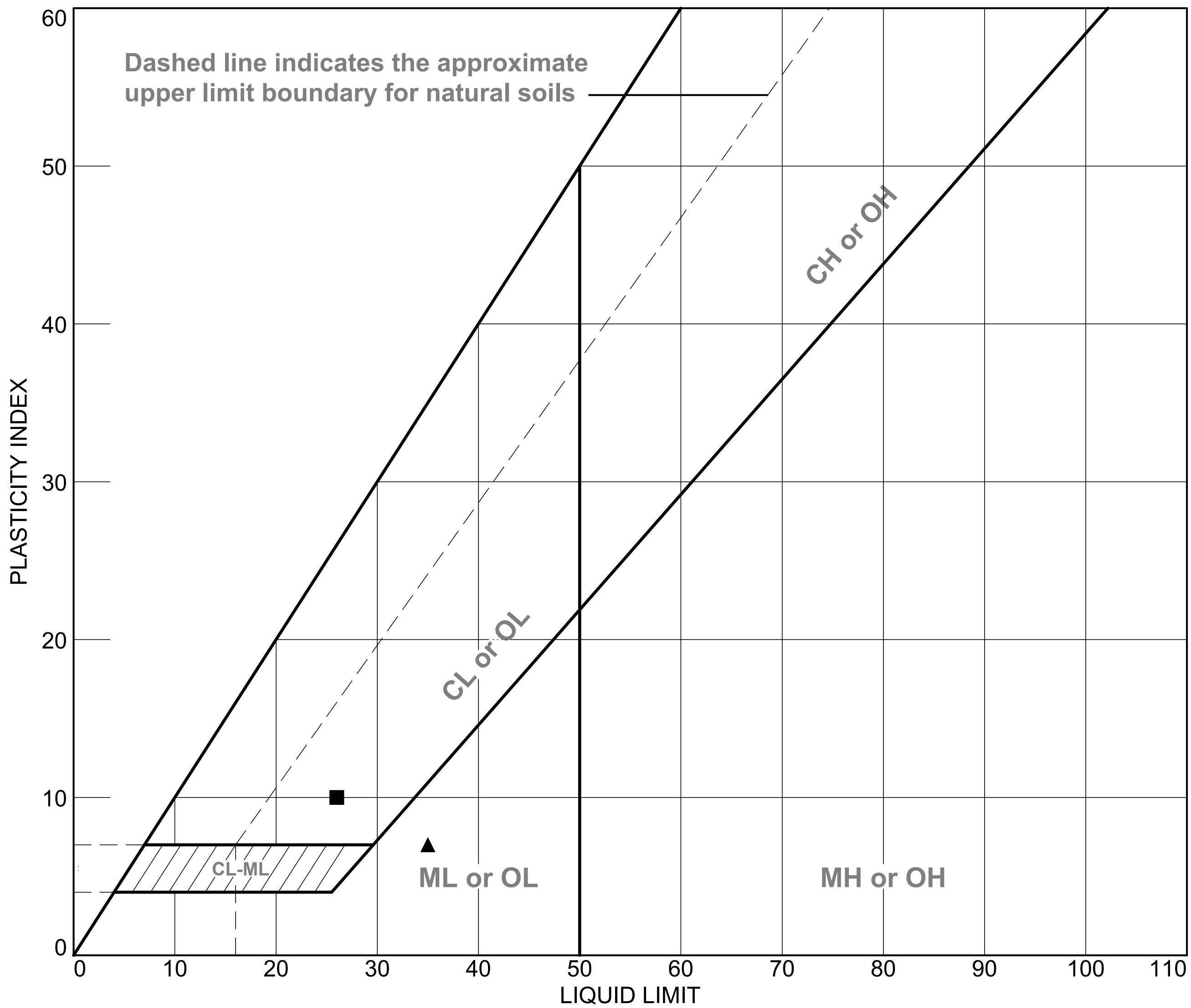
Client: Geosyntec - Simone Smith

Project: Geosyntec-Delaware Valley Works

Project No.: P20014

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



SOIL DATA

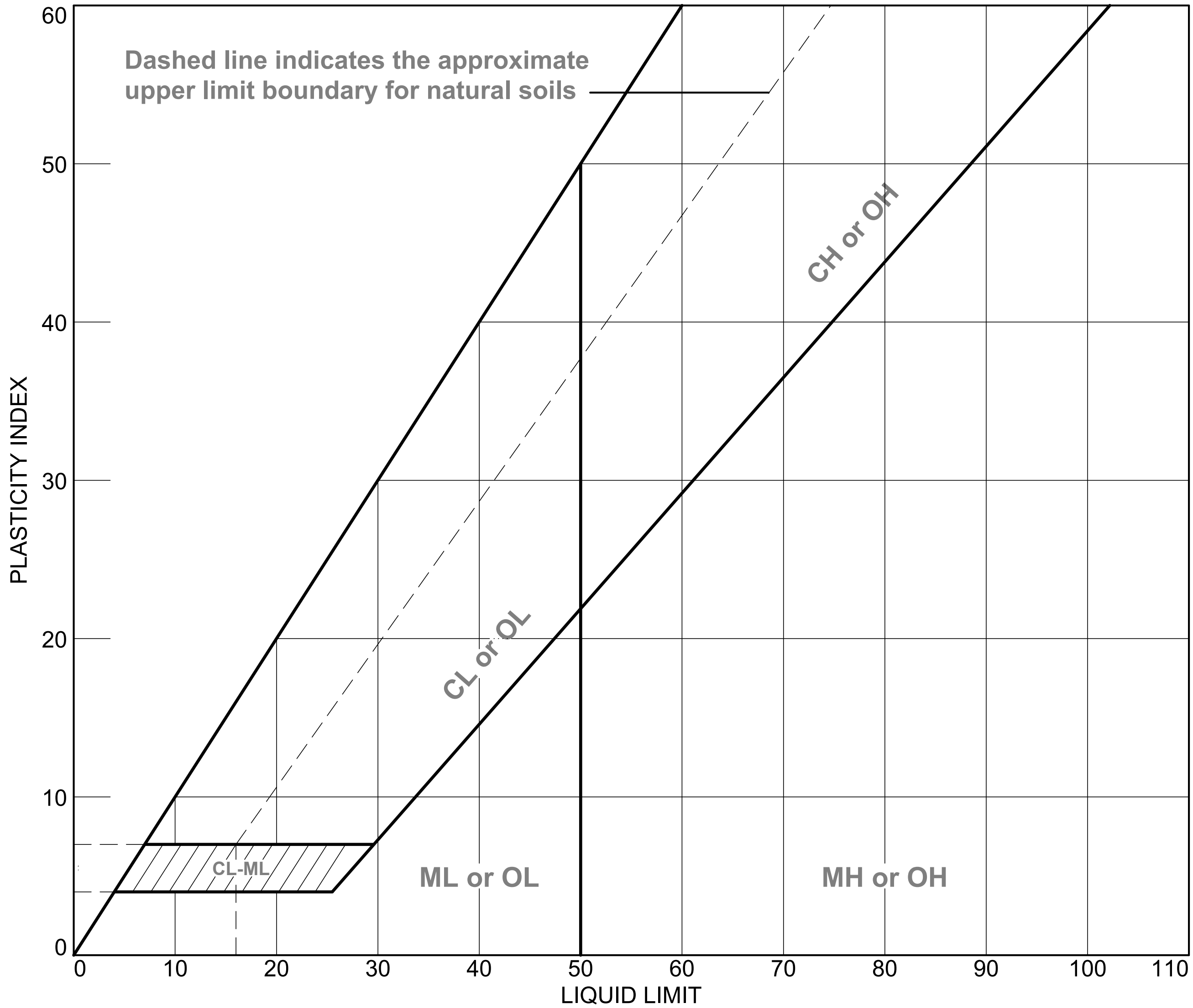
SYMBOL	SOURCE	SAMPLE NO.	DEPTH	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	B-20-20	13	50	28.1	NP	NV	NP	SM
■	B-20-20	10	35.5	21.6	16	26	10	SC
▲	B-20-20	ST-1	28	29.6	28	35	7	

HILLIS-CARNES ENGINEERING ASSOCIATES **Philadelphia, Pennsylvania**	**Client:** Geosyntec - Simone Smith **Project:** Geosyntec-Delaware Valley Works **Project No.:** P20014 **Figure**

These results are for the exclusive use of the client for whom they were obtained. They apply only to the samples tested and are not indicitive of apparently identical samples

These results are for the exclusive use of the client for whom they were obtained. They apply only to the samples tested and are not indicitive of apparently identical sample

LIQUID AND PLASTIC LIMITS TEST REPORT



SOIL DATA								
SYMBOL	SOURCE	SAMPLE NO.	DEPTH	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	B-21-20	SPT2	2	6.2	25	25	NP	SM
■	B-21-20	ST-1	18	46.7	NP	37	NP	

HILLIS-CARNES ENGINEERING ASSOCIATES

Philadelphia, Pennsylvania

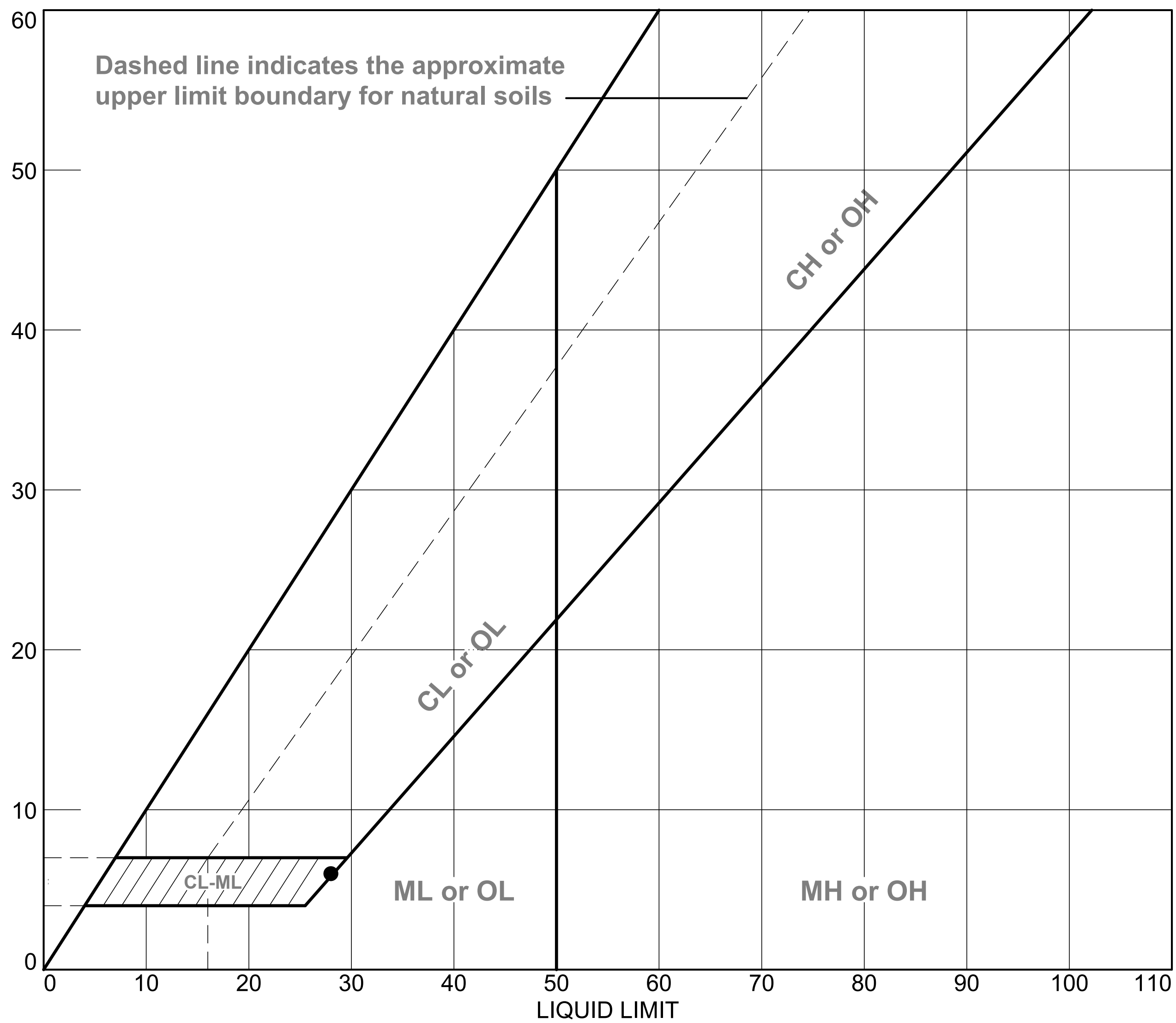
Client: Geosyntec - Simone Smith

Project: Geosyntec-Delaware Valley Works

Project No.: P20014

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



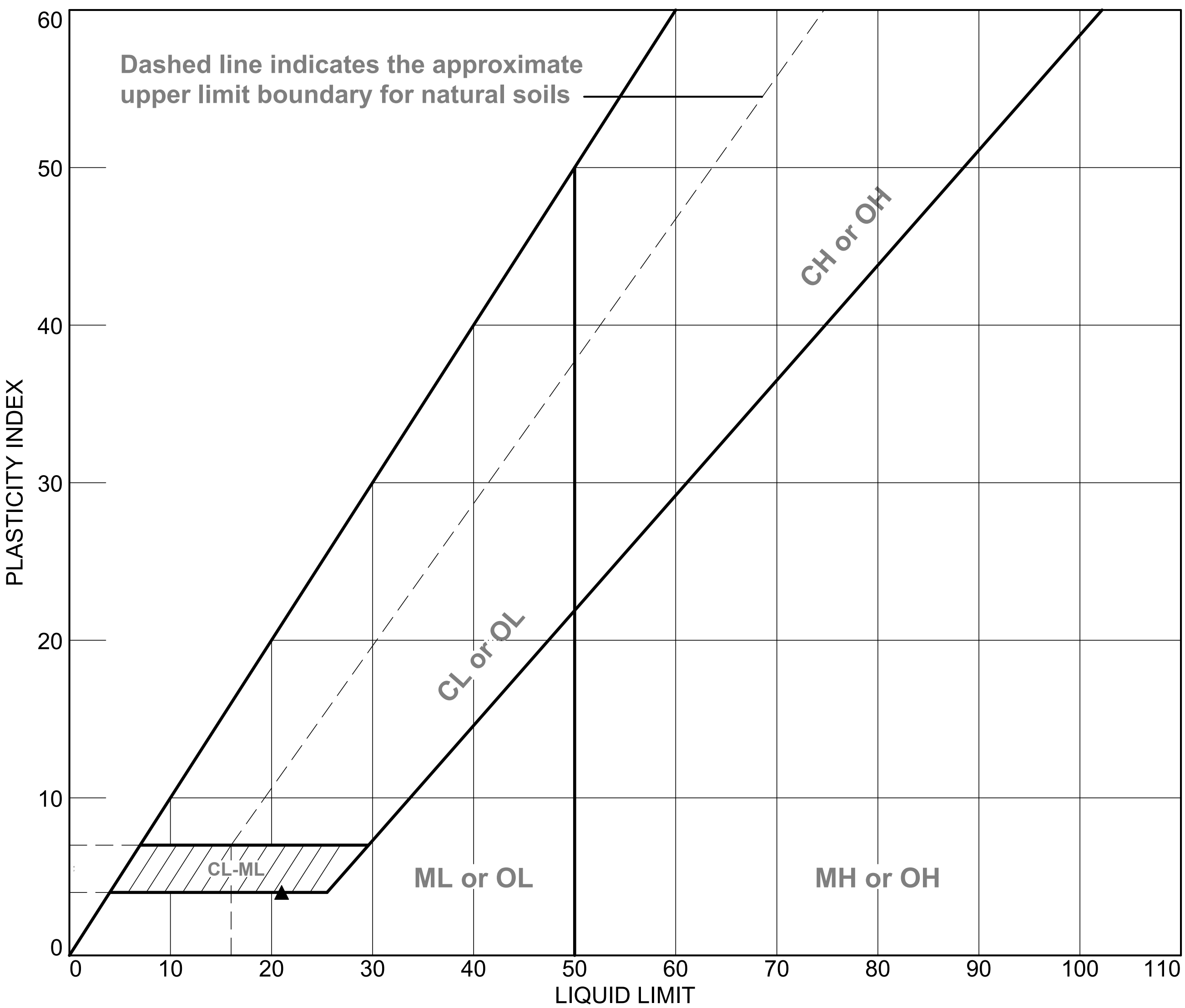
SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	B-22-20	ST-1	18	17.8	22	28	6	CL-ML

HILLIS-CARNES ENGINEERING ASSOCIATES	**Client:** Geosyntec - Simone Smith
	Project: Geosyntec-Delaware Valley Works
Philadelphia, Pennsylvania	**Project No.:** P20014 **Figure**

These results are for the exclusive use of the client for whom they were obtained. They apply only to the samples tested and are not indicitive of apparently identical samples.

LIQUID AND PLASTIC LIMITS TEST REPORT



SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	B-24-20	SPT4	6.3	21.8	NP	32	NP	SM
■	B-24-20	SPT9	31	80.1	NP	NV	NP	GM
▲	B-24-20	ST-1	13	21.3	17	21	4	CL-ML

HILLIS-CARNES ENGINEERING ASSOCIATES

Philadelphia, Pennsylvania

Client: Geosyntec - Simone Smith

Project: Geosyntec-Delaware Valley Works

Project No.: P20014

Figure

Organic Content Testing Summary

Boring ID	Sample ID	Sample Depth (ft)	Organic Content (%)	Sample Description
B-17-20	SPT-8	31.00-31.50	5	Black, wet, silt, trace organics
B-19-20	ST-1	18.00-20.00	7.3	Brown with some gray, moist, sandy silt, apparent wood
B-21-20	ST-1	18.00-20.00	5.1	Black/brown, wet, silty sand

Measurement of Hydraulic Conductivity (ASTM D 5084-03 Method F)

Mix No.:
Sample No.: **B-16-20**
Date Tested: 4/2/2020

Sample Type: Extracted from Shelby Tube

Initial			**Final**		
Mass	990.24	g.	Mass	1006.67	g.
Length	7.125	in.	Length	7.125	in.
Diameter	2.800	in.	Diameter	2.800	in.
Volume	0.0254	ft^3	Volume	0.0254	ft^3

Type of Permeant Liquid Used: deaired Tap Water

Initial hydraulic gradient:
Final hydraulic gradient:

Specific Gravity 2.65 Estimated

Confining Pressure 50 psi
Back Pressure 40 psi

Temp 23 °C

Corrected Hydraulic Conductivity (k_{20}) @ **3.13E-07** **cm/sec**

Soil Description

Project No. P20014
Client: Geosyntec Consultants
Remarks:

Project:
Delaware Valley Works
Date: 1-May-20

Measurement of Hydraulic Conductivity

Hillis-Carnes Engineering Associates

Measurement of Hydraulic Conductivity (ASTM D 5084-03 Method F)

Mix No.:
Sample No.: **B-17-20**
Date Tested: 5/1/2020

Sample Type: Extracted from Shelby Tube

Initial			**Final**		
Mass	991.81	g.	Mass	926.70	g.
Length	5.750	in.	Length	5.750	in.
Diameter	2.800	in.	Diameter	2.800	in.
Volume	0.0205	ft^3	Volume	0.0205	ft^3

Type of Permeant Liquid Used: deaired Tap Water

Initial hydraulic gradient:
Final hydraulic gradient:

Specific Gravity 2.65 Estimated

Confining Pressure 50 psi
Back Pressure 40 psi

Temp 23 °C

Corrected Hydraulic Conductivity (k_{20}) @ **3.62E-06** **cm/sec**

Soil Description

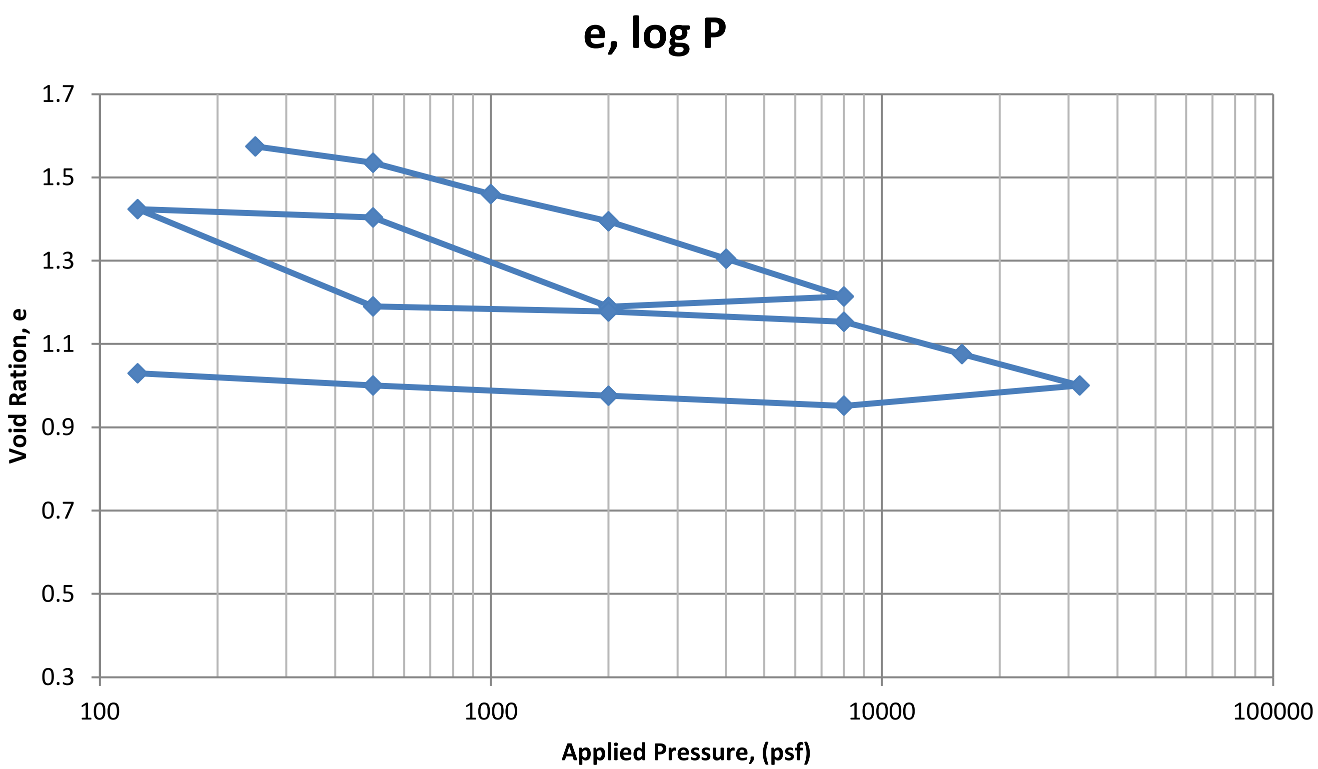
Project No. P20014
Client: Geosyntec Consultants
Remarks:

Project:
Delaware Valley Works
Date: 1-May-20

Measurement of Hydraulic Conductivity

Hillis-Carnes Engineering Associates

Consolidation Test Report



Material Description	USCS	AASHTO
Gray fine Silty SAND	SM	A-2-4(0)

LL	29
PI	NP
Sg	3.14

	Init	Final
Dry Density (pcf)	79.6	101.2
Moisture	0.398	0.298
Saturation	0.854	1.000
Void Ratio	1.589	0.937

Pc (psf)	Cc
950	0.25

Preparation:

Shelby tube extraction

Notes:

Proj. No. P20014 Client: Geosyntec

Project: Geosyntec-DVW

Sample: B-17-20, ST-1

Depth: 0

Hillis-Carnes Engineering Associates

Media, Pennsylvania

HILLIS-CARNES
ENGINEERING ASSOCIATES

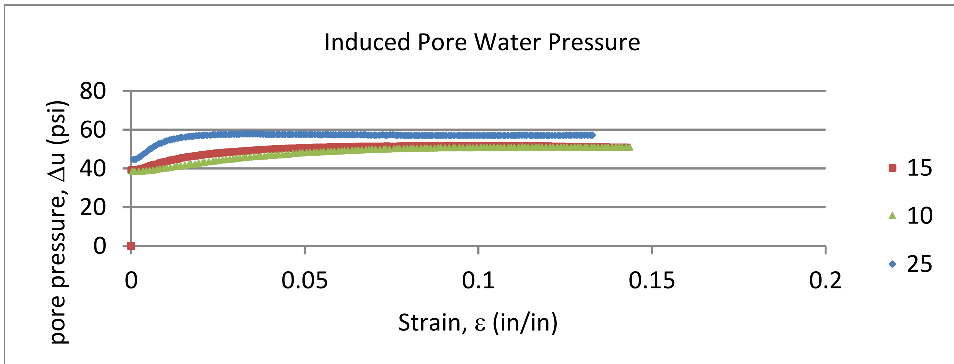
300 South Pennell Road, Suite 410
Media, Pennsylvania 19063
484-434-1000

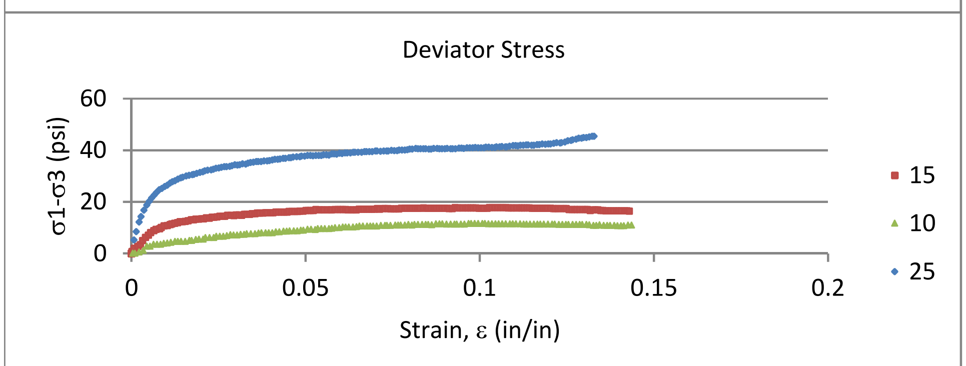
Client: Geosyntec Consultants
Project: Delaware Valley Works
Project No.: P20014

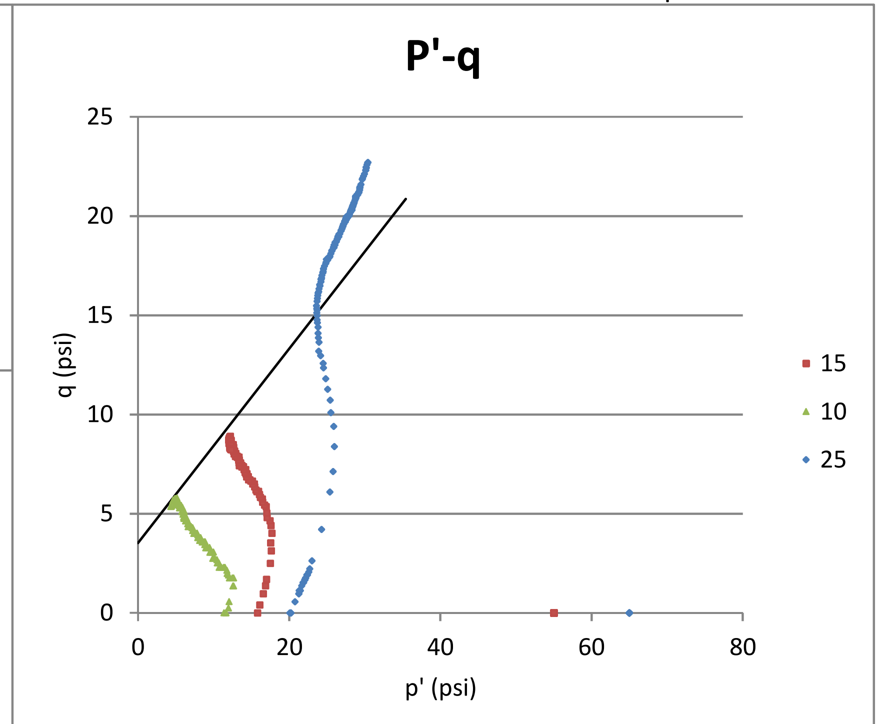
ASMT D 4767 - Consolidated Undrained Triaxial Compression

Sample: B-17-20
Sample Preparation: Test 1 & Test 2 extracted; Test 3 remolded; Pressure data estimated for test 2
Failure envelope adjusted to discount remolded strength gain of point 3

Test No.	Water Content	Dry Density (pcf)	Wet Density (pcf)	Consolidation Pressure (psi)	Max.Deviator Stress (psi)	Strain at Failure		
							ϕ =	29.3°
1	53.8%	68.2	104.9	15	17.8	10.3%	c =	582 psf
2	56.0%	67.3	104.9	10	11.6	9.7%	α =	26.1°
3	36.6%	64.9	88.6	25	45.4	13.2%	a =	507 psf







Measurement of Hydraulic Conductivity (ASTM D 5084-03 Method F)

Mix No.:
Sample No.: **B-19-20**
Date Tested: 5/1/2020

Sample Type: Extracted from Shelby Tube

Initial			**Final**		
Mass	1275.17	g.	Mass	1434.58	g.
Length	7.125	in.	Length	7.125	in.
Diameter	2.800	in.	Diameter	2.800	in.
Volume	0.0254	ft^3	Volume	0.0254	ft^3

Type of Permeant Liquid Used: deaired Tap Water

Initial hydraulic gradient:
Final hydraulic gradient:

Specific Gravity: 2.65 Estimated

Confining Pressure: 50 psi
Back Pressure: 40 psi

Temp: 23 °C

Corrected Hydraulic Conductivity (k_{20}) @ **1.17E-07** **cm/sec**

Soil Description:

Project No.	P20014	**Client:**	Geosyntec Consultants
Project: **Delaware Valley Works**		**Date:**	1-May-20

Remarks:

Measurement of Hydraulic Conductivity

Hillis-Carnes Engineering Associates

HILLIS-CARNES
ENGINEERING ASSOCIATES

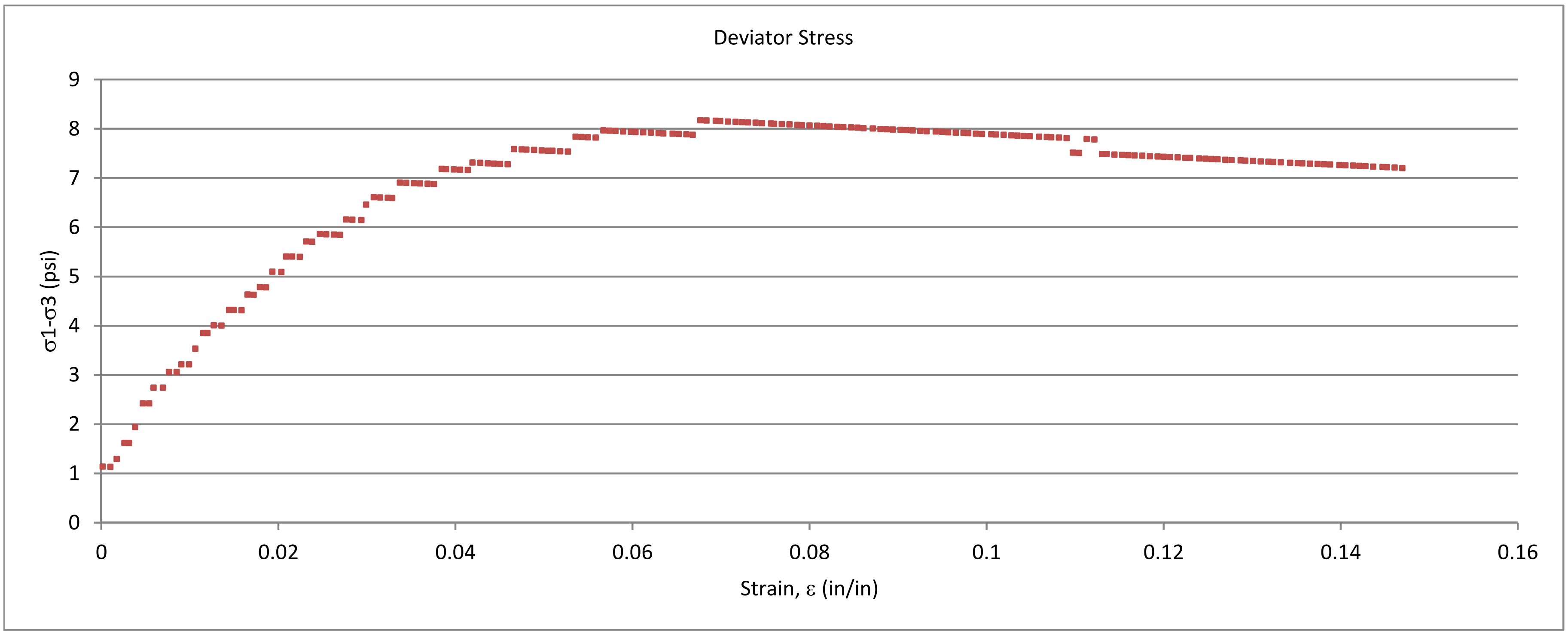
300 South Pennell Road, Suite 410
Media, Pennsylvania 19063
484-434-1000

Client: Geosyntec Consultants
Project: Delaware Valley Works
Project No.: P20014

ASTM D 2850 - Unconsolidated Undrained Triaxial Compression

Sample: B-17-20
Sample Preparation: tube extracted

Test No.	Water Content	Dry Density (pcf)	Wet Density (pcf)	Confinement Pressure (psi)	Max.Deviator Stress (psi)	Strain at Failure
1	62.9%	68.4	111.4	20	8.2	6.8%



Measurement of Hydraulic Conductivity (ASTM D 5084-03 Method F)

Mix No.:
Sample No.: **B-21-20**
Date Tested: 5/1/2020

Sample Type: Extracted from Shelby Tube

Initial			**Final**		
Mass	880.09	g.	Mass	1072.88	g.
Length	5.750	in.	Length	5.750	in.
Diameter	2.800	in.	Diameter	2.800	in.
Volume	0.0205	ft^3	Volume	0.0205	ft^3

Type of Permeant Liquid Used: deaired Tap Water

Initial hydraulic gradient:
Final hydraulic gradient:

Specific Gravity: 2.65 Estimated

Confining Pressure: 48 psi
Back Pressure: 40 psi

Temp: 23 °C

Corrected Hydraulic Conductivity (k_{20}) @ **5.69E-07** **cm/sec**

Soil Description:

Project No.	P20014	**Client:**	Geosyntec Consultants
Project: **Delaware Valley Works**		**Date:**	1-May-20

Remarks:

Measurement of Hydraulic Conductivity

Hillis-Carnes Engineering Associates

HILLIS-CARNES
ENGINEERING ASSOCIATES

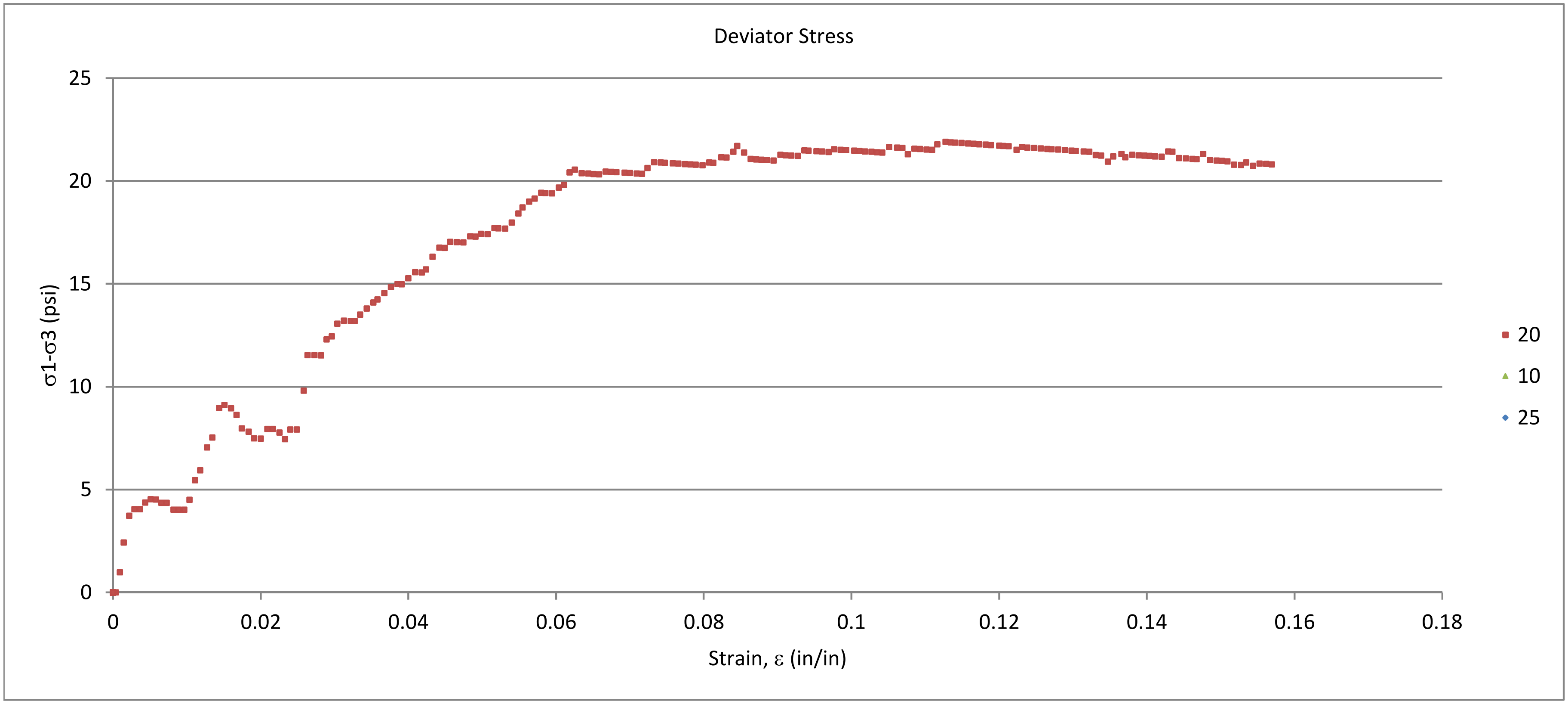
300 South Pennell Road, Suite 410
Media, Pennsylvania 19063
484-434-1000

Client: Geosyntec Consultants
Project: Delaware Valley Works
Project No.: P20014

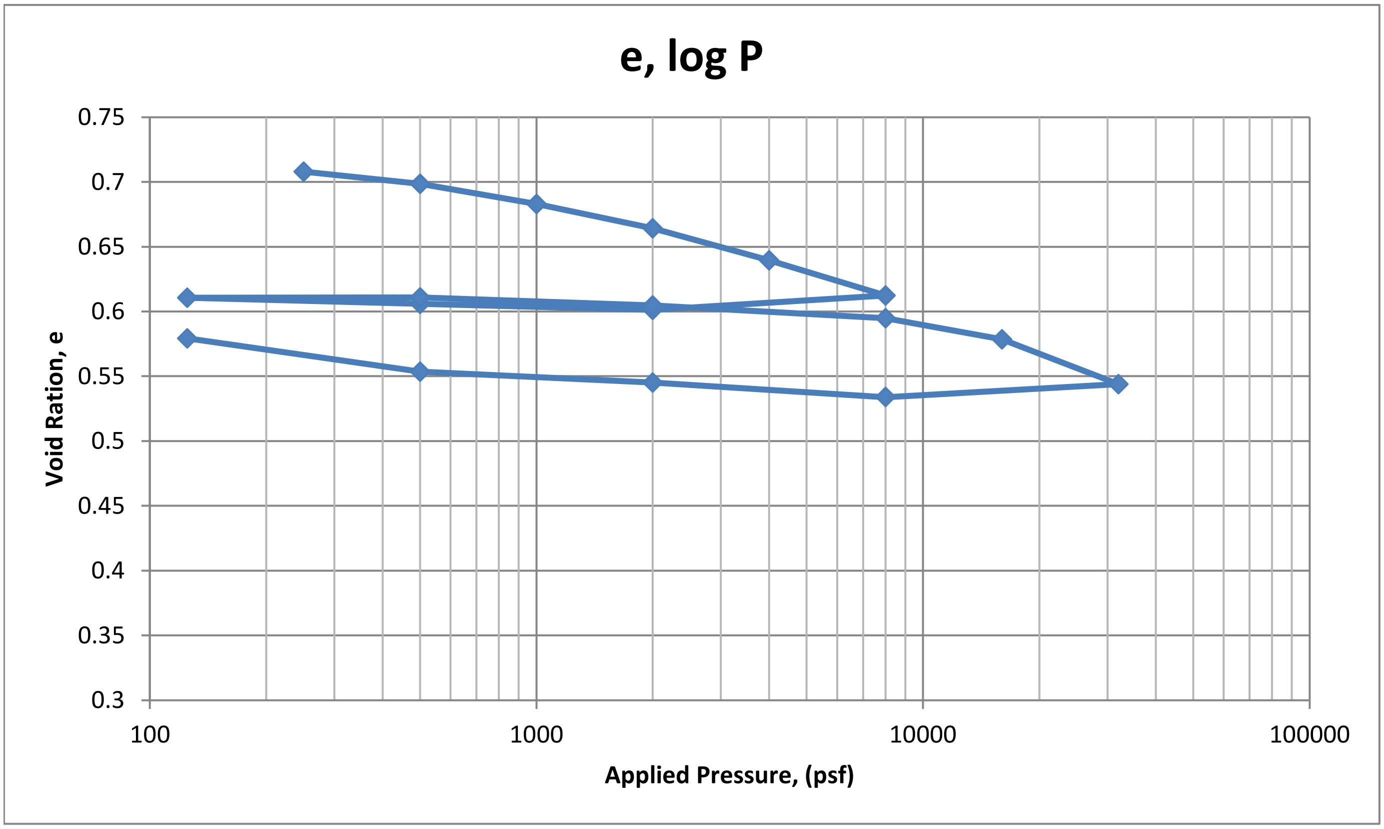
ASTM D 2850 - Unconsolidated Undrained Triaxial Compression

Sample: B-17-20
Sample Preparation: Extracted

Test No.	Water Content	Dry Density (pcf)	Wet Density (pcf)	Confinement Pressure (psi)	Max.Deviator Stress (psi)	Strain at Failure
1	45.9%	61.7	90.0	20	21.9	11.3%



Consolidation Test Report



Material Description	USCS	AASHTO
Brown/gray Silt-Clay	CL-ML	A-1-b

LL	21
PI	4
Sg	2.95

	Init	Final
Dry Density (pcf)	119.5	116.8
Moisture	0.213	0.196
Saturation	1.157	1.000
Void Ratio	0.709	0.579

Pc (psf)	Cc
2270	0.11

Preparation:

Shelby tube extraction

Notes:

Proj. No. P20014 Client: Geosyntec
Project: Geosyntec-DVW
Sample: B-17-20, ST-1
Depth: 13-15'

Hillis-Carnes Engineering Associates

Media, Pennsylvania

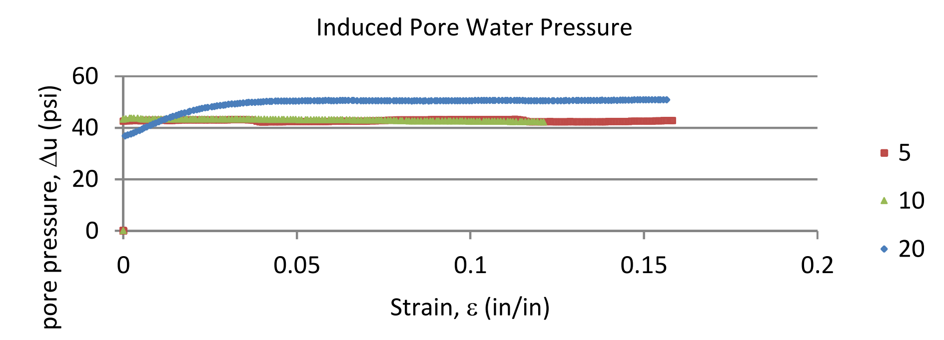
300 South Pennell Road, Suite 410
Media, Pennsylvania 19063
484-434-1000

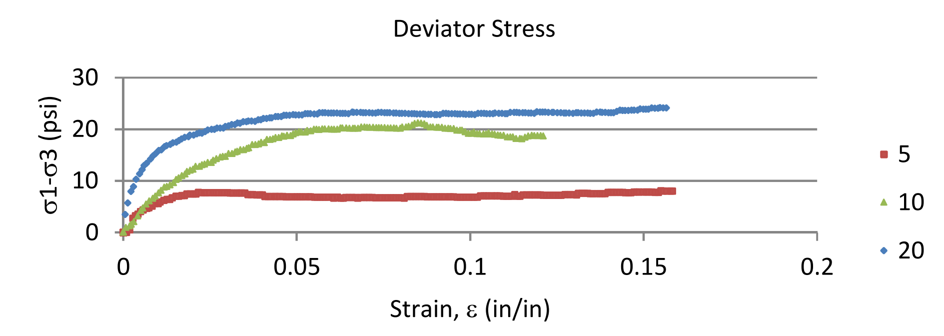
Client: Geosyntec Consultants
Project: Delaware Valley Works
Project No.: P20014

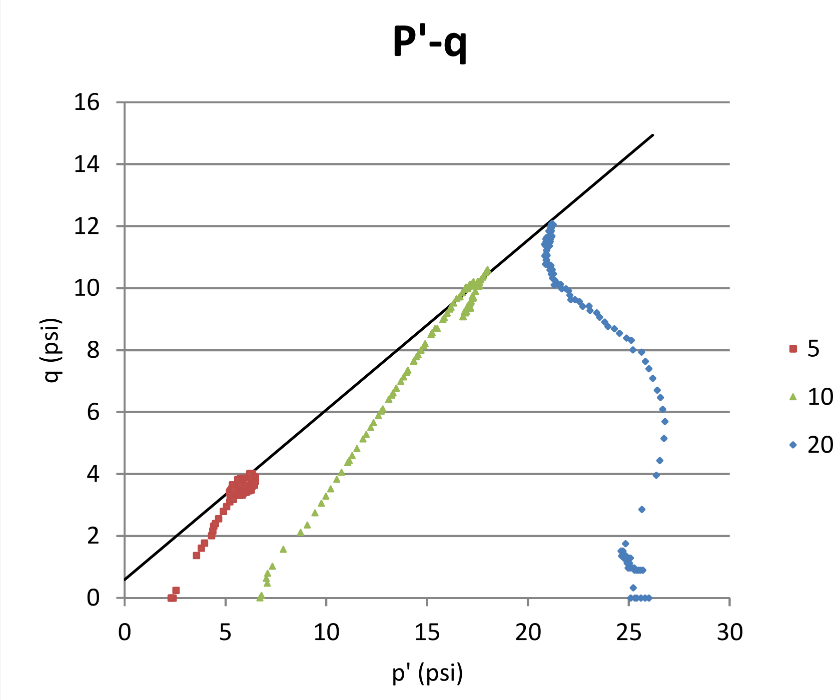
ASMT D 4767 - Consolidated Undrained Triaxial Compression

Sample: B-24-20
Sample Preparation: Test 1, Test 2, and Test 3 extracted

Test No.	Water Content	Dry Density (pcf)	Wet Density (pcf)	Consolidation Pressure (psi)	Max.Deviator Stress (psi)	Strain at Failure		
							ϕ =	33.2°
1	24.3%	95.4	118.6	5	8.0	15.5%	c =	101 psf
2	22.0%	112.5	137.3	10	21.2	8.5%	α =	28.7°
3	19.8%	86.3	103.4	20	24.2	15.5%	a =	85 psf







APPENDIX C

DESIGN PARAMETERS

Geosyntec
consultants

CALCULATION PACKAGE COVER SHEET

Client: Drawbridge Claymont **Project:** Delaware Valley Works Pre-Design Investigation **Project No.:** JR0272 **Task #:** 03

TITLE OF COMPUTATION Geotechnical Soil Properties

COMPUTATIONS BY:
Signature
06/22/2020
DATE
Printed Name and Title: Andrew M. Stallings, P.E. (MD) Engineer

ASSUMPTIONS AND PROCEDURES CHECKED BY:
(Peer Reviewer)
Signature
06/26/2020
DATE
Printed Name and Title: Zichang Li, Ph.D., P.E. (MD) Engineer

COMPUTATIONS CHECKED BY:
Signature
06/26/2020
DATE
Printed Name and Title: Zichang Li, Ph.D., P.E. (MD) Engineer

COMPUTATIONS BACKCHECKED BY:
(Originator)
Signature
6/26/2020
DATE
Printed Name and Title: Andrew M. Stallings, P.E. (MD) Engineer

APPROVED BY:
(PM or Designate)
Signature
11/16/2020
DATE
Printed Name and Title: R. David Espinoza, Ph.D., P.E. (DE) Senior Principal

APPROVAL NOTES:

REVISIONS (Number and initial all revisions)

NO.	SHEET	DATE	BY	CHECKED BY	APPROVAL

GEOTECHNICAL SOIL PROPERTIES

1 PURPOSE AND SCOPE

Geosyntec Consultants, Inc. (Geosyntec) has prepared a Pre-Design Investigation (PDI) Report for the Delaware Valley Works (DVW) South Parcel, Phase 2 (the Site) located in Claymont, Delaware. The total area of the Site is approximately 22 acres. The purpose of this report is to develop recommended geotechnical soil properties that may be used for the design of a low permeability cap at the Site and for potential future development of the Site.

The geotechnical soil properties developed herein are based on a recent investigation performed by Geosyntec in 2020 at the Site and an investigation performed by AECOM on the South Parcel, Phase 1 (i.e., northern portion of the South Parcel) in 2015 and 2016 [AECOM, 2017]. Data obtained from these investigations will be used for the design of the low permeability cap. Additional field and laboratory investigations may be necessary to develop the Site after construction of the low permeability cap to supplement the data presented herein.

2 FIELD AND LABORATORY INVESTIGATIONS

In 2015 and 2016, fifteen borings were advanced under AECOM supervision using a truck-mounted CME-55 drilling rig: eight using hollow-stem auger (HSA) drilling techniques (B-1 through B-8) and seven using mud rotary drilling techniques (B-9 through B-15). Samples were obtained using split-barrel samplers and thin-walled tube samplers (i.e., Shelby tubes). Penetration resistance was recorded during standard penetration tests (SPTs) to gauge the relative density of subsurface materials and a pocket penetrometer was used on fine-grained samples to estimate soil consistency and unconfined compressive strength.

In 2020, nine borings (B-16-20 to B-24-20) were advanced under Geosyntec supervision using a truck-mounted Diedrich D120 HSA. Samples were obtained using split-barrel samplers and thin-walled tube samplers (i.e., Shelby tubes). Penetration resistance was recorded during SPTs to gauge the relative density of subsurface materials and a pocket penetrometer was used on fine-grained samples to estimate soil consistency and unconfined compressive strength.

During these field investigations, groundwater was generally encountered at depths ranging from approximately 4 to 15 ft below ground surface (ft-bgs), which corresponds to groundwater elevations between approximately -3.5 and +7.5 ft.

Laboratory testing was performed to characterize and determine index properties of soil samples, and included: moisture content, Atterberg limits, grain size distribution, and organic content. Additionally, undisturbed samples obtained with Shelby tubes were subject to the following laboratory tests:

- Seven (7) falling head permeability tests were performed to determine hydraulic conductivities of soils.

- Eleven (11) one-dimensional incremental loading consolidation tests were performed to determine compressibility properties of soils.

- Twelve (12) unconsolidated-undrained (UU) and two (2) consolidated-undrained (CU) triaxial compression tests were performed to assess the shear strength properties of soils.

3 SUBSURFACE CHARACTERIZATION

Based on the information described in Section 2, the subsurface is subdivided into the following strata:

- Stratum 1 (Fill) – brown, loose to very dense silty sand and gravel (upper), stiff sandy silty clay (lower), with brick, concrete, and wood.
- Stratum 2 – dark gray, soft to medium stiff silty clay and clayey silt, with organics.
- Stratum 3 – brown, stiff to very stiff sandy silty clay and clayey silt.
- Stratum 4 – brown and gray, medium dense to very dense silty sand and gravel.
- Stratum 5 (Residual Soil) – gray and light gray, dense to very dense silty sand, very stiff to hard sandy silt and silty clay, with relict rock structure.
- Stratum 6 (Decomposed Rock) – light gray and dark gray, very dense silty sand, hard sandy silty clay and clayey silt, with relict rock structure.

Bedrock at the Site consists of Wilmington Complex Ardentown Granitic Suite from the Silurian Period [Schenk et al., 2000]. Geotechnical properties are not developed for bedrock herein.

4 GEOTECHNICAL CHARACTERIZATION

4.1 Density Properties

Plots, tabulated data, and technical references used to determine density properties of soils are included as Attachment I.

4.1.1 Density Properties of Coarse-Grained Strata

Unit weights for coarse-grained strata are typically not measured directly but inferred through correlations. For this case, the relationship proposed by Mitchell and Katti [1981] that correlates density with relative density was used to estimate the dry unit weight of these strata based on the relative density of these materials. These strata generally increased in relative density with depth.

Stratum 1 was generally in a loose to very dense relative density state. Therefore, a dry unit weight (γ_d) of **108.2 pcf** (17 kN/m^3) is recommended. Based on a mean water content (ω) of **21.3 percent**, the total (moist) unit weight (γ_t) can be calculated as **131.2 pcf** using the following equation:

$$\gamma_t = \gamma_d \left(1 + \frac{\omega\%}{100\%}\right) \tag{1}$$

Stratum 4 was generally in a medium dense to very dense relative density state. Therefore, a dry unit weight of **114.6 pcf** (18 kN/m^3) is recommended. Based on a mean water content of **20.7 percent**, the total unit weight can be calculated as **138.3 pcf** using Equation 1.

Stratum 5 was generally in a dense to very dense relative density state. Therefore, a dry unit weight of **121.0 pcf** (19 kN/m^3) is recommended. Based on a mean water content of **35.4 percent**, the total unit weight can be calculated as **163.8 pcf** using Equation 1.

Stratum 6 was generally in a very dense relative density state. Therefore, a dry unit weight of **127.3 pcf** (20 kN/m^3) is recommended. No water content data was obtained for Stratum 6. Based on a mean water content of **35.4 percent** from Stratum 5, the total unit weight can be calculated as **172.4 pcf** using Equation 1.

The unit weights for Stratum 5 and Stratum 6 are abnormally high for typical soils. However, relict granitic rock structures in these strata may be contributing to the high unit weight. Rock masses can typically have a unit weight of 170 pcf (27 kN/m^3) [Hoek, 2007].

4.1.2 Density Properties of Fine-Grained Strata

Dry and total unit weights of fine-grained strata were obtained where sample dimensions, weight, and water content were measured in the laboratory for other tests on undisturbed samples. Measured unit weights were plotted against depth to see if any trends were evident.

There was no apparent trend with depth for Stratum 2, with the exception of eight samples shallower than 15 ft-bgs which had much larger unit weights than other samples. It is possible that these shallower samples may be in a transitional zone from Stratum 1 which is expected to have higher unit weights than Stratum 2. Therefore, these eight samples were ignored when determining mean unit weights of Stratum 2. The mean dry unit weight was **50.7 pcf** and the mean total unit weight was **91.1 pcf**. These low unit weights are typical for highly organic soils and peats.

There was no apparent trend with depth for Stratum 3. The mean dry unit weight was **104.1 pcf** and the mean total unit weight was **127.6 pcf**.

4.2 Hydraulic Conductivity

Plots, tabulated data, and technical references used to determine saturated vertical hydraulic conductivity of soils are included as Attachment II.

4.2.1 Saturated Hydraulic Conductivity of Coarse-Grained Strata

Hydraulic conductivities of coarse-grained strata were not directly measured. Instead, hydraulic conductivities were estimated from sieve analysis results using the Kozeny-Carman formula as presented in Carrier [2003]. This semi-empirical, semi-theoretical formula for predicting the permeability of porous materials is based on the entire particle size distribution of the soil, the particle shape, and the void ratio.

Samples from Stratum 1 generally classified as silty sand and gravel. Estimated vertical hydraulic conductivities ranged from 1.6×10^{-6} centimeters per second (cm/s) to 2.9×10^{-4} cm/s with a geometric mean of **2.2×10^{-5} cm/s**. These values fall within the range of values presented in Terzaghi et al. [1996] for typical mixtures of sand, silt, and clay (1.0×10^{-7} cm/s to 1.0×10^{-3} cm/s). One sample obtained from Stratum 1 at borehole B-15 classified as sandy lean clay and was not considered in the estimate. The Kozeny-Carman formula assumes there are no electrochemical reactions between soil particles and pore water. Therefore, the formula is applicable for coarse materials and nonplastic silts but not for clayey soils.

Samples from Stratum 4 generally classified as silty sand and gravel. Estimated vertical hydraulic conductivities ranged from 1.8×10^{-6} cm/s to 3.2×10^{-4} cm/s with a geometric mean of **2.2×10^{-5} cm/s**. These values fall within the range of values presented in Terzaghi et al. [1996] for typical mixtures of sand, silt, and clay (1.0×10^{-7} cm/s to 1.0×10^{-3} cm/s).

4.2.2 Saturated Hydraulic Conductivity of Fine-Grained Strata

Hydraulic conductivities of samples obtained from fine-grained strata (i.e., Stratum 2 and Stratum 3) were estimated from seven flexible-wall triaxial permeability tests. Test specimens were generally consolidated to the mean effective stress they were originally subjected to in the field in order to evaluate the hydraulic conductivity of soils within the stress range of interest for the site. Falling head hydraulic conditions were used for permeability tests.

Samples from Stratum 2 generally classified as silty clay and clayey silt with organics. Vertical hydraulic conductivity results from permeability tests performed on samples from Stratum 2 ranged from 1.2×10^{-7} cm/s to 3.6×10^{-6} cm/s with a geometric mean of **4.7×10^{-7}** cm/s. These values are similar to the lower bound of the range of values presented in Terzaghi et al. [1996] for typical mixtures of sand, silt, and clay (1.0×10^{-7} cm/s to 1.0×10^{-3} cm/s).

One-dimensional incremental loading consolidation tests were also performed on samples obtained from Stratum 2. For consolidation tests where time-deformation measurements were recorded for each load increment, hydraulic conductivities were back-calculated based on the rate of consolidation. Vertical hydraulic conductivity results from consolidation tests performed on samples from Stratum 2 ranged from 3.2×10^{-8} cm/s to 1.3×10^{-7} cm/s with a geometric mean of 7.3×10^{-8} cm/s. These back-calculated values are less permeable than, but comparable to hydraulic conductivities obtained from permeability tests.

Samples from Stratum 3 generally classified as sandy silty clay and clayey silt. Vertical hydraulic conductivity results from one permeability test performed on a sample from Stratum 3 had a result of **4.2×10^{-7} cm/s**. This value is similar to the lower bound of the range of values presented in Terzaghi et al. [1996] for typical mixtures of sand, silt, and clay (1.0×10^{-7} cm/s to 1.0×10^{-3} cm/s).

4.2.3 Soil Anisotropy

Soil deposits are generally anisotropic with horizontal stratification due to horizontal bedding in natural deposits or construction in horizontal lifts for fill materials, usually resulting in horizontal hydraulic conductivity being greater than vertical hydraulic conductivity. Anisotropy is defined by the ratio of horizontal hydraulic conductivity (k_h) to vertical hydraulic conductivity (k_v). Laboratory testing usually measures the value of vertical hydraulic conductivity consistent with the orientation of borehole samples.

Natural soils deposited by water such as fluvial deposits are typically stratified and may have anisotropy ratios greater than 100 [USBR, 2014]. For example, coarse-grained strata may exist within the fine-grained strata at the Site which could significantly increase horizontal hydraulic conductivity. While vertical hydraulic conductivity will be controlled by the fine-grained materials, horizontal hydraulic conductivity will be controlled by the coarse-grained interlayers. If anisotropy ratios are needed to model seepage at the Site for future development, it is suggested to perform a parametric study in which anisotropy ratios of 1, 10, 25, and 100 are considered [USACE, 1986]. No anisotropy ratio is recommended at this time due to lack of field testing data to characterize horizontal hydraulic conductivity of soils (e.g., slug tests, pore pressure dissipation tests).

Coarse-grained deposits such as the surficial fill layer and the deeper silty sand layers are usually assigned an anisotropy ratio of 1.0 but can usually range from 1.0 to 3.0 [USBR, 2014]. It may be expected that the deeper natural coarse-grained deposits may have anisotropy ratios at the higher end of this ratio while the surficial fill layer was likely placed in thicker lifts without much compactive effort, resulting in a lower anisotropy ratio.

4.3 Compressibility

Plots and tabulated data used to determine compressibility properties of soils are included as Attachment III. Results from SPT results, which are included as Attachment IV, were also used to develop elastic properties of coarse-grained soils.

4.3.1 Primary Consolidation Properties

Settlements of fine-grained strata are generally attributed to primary consolidation (time and load dependent) and secondary settlement (time dependent). Immediate elastic settlements are considered negligible when compared to settlements that will occur due to primary and secondary consolidation processes. Consolidation properties of samples obtained from fine-grained strata (i.e., Stratum 2) were estimated from eleven one-dimensional incremental-loading consolidation tests.

The rate at which primary consolidation occurs is defined by the compression ratio ($C_{\varepsilon c}$) and the recompression ratio ($C_{\varepsilon r}$). The compression ratio defines the stress-strain relationship of soil while in virgin compression and the recompression ratio defines the stress-strain relationship of soil while in recompression. Given a change in applied stress, the magnitude of consolidation will be greater during virgin compression (i.e., the soil experiencing a larger stress state than it has experienced previously) versus recompression (i.e., the soil has been previously unloaded and subsequently reloaded through a stress state is has experienced previously). For Stratum 2, the compression ratio ranged from 0.160 to 0.408 with a mean value of **0.296**. The recompression ratio ranged from 0.017 to 0.054 with a mean value of **0.036**.

Preconsolidation stress is the maximum stress that the soil has experienced previously and defines the stress at which consolidation transitions from recompression into virgin compression. Preconsolidation stress is important to define because deformations under equal stress changes will vary greatly depending on whether a soil is in virgin compression or recompression. The degree to which soil has previously exceeded its current in situ stress state is defined by the overconsolidation ratio (OCR), which is the ratio of preconsolidation stress to in situ stress. For Stratum 2, OCR ranged from 1.3 to 2.6 with a mean value of **2.0**, indicating the soil is lightly overconsolidated. Differences in OCR did not appear to correspond to different areas at the Site. However, when multiple consolidation tests were performed at a single borehole, calculated OCR values were consistent at each borehole. Additional compressibility tests may be necessary for future development of the Site depending upon the serviceability restrictions determined by the infrastructure use.

Of the eleven samples tested, results from three samples (B-11 at 12.0 ft-bgs, B-17-20 at 21.5 ft-bgs, and B24-20 at 14.0 ft-bgs) were ignored because their consolidation curves had no clearly defined point of maximum curvature. Samples may have been subjected to significant sample disturbance or contained a larger-than-expected coarse-grained content. Compressibility parameters from these tests were generally smaller than other tests. Thus, ignoring these results is considered conservative.

Compressibility properties of Stratum 3 was not determined with consolidation tests. Stratum 3 is generally similar to Stratum 2 but slightly stiffer and with less organics. Thus, compressibility properties obtained for Stratum 2 may be conservatively used for Stratum 3.

4.3.2 Secondary Consolidation Properties

Secondary consolidation settlement is generally attributed to continued particle rearrangement and creep following primary consolidation. The rate at which secondary consolidation occurs is defined by the secondary compression ratio ($C_{\varepsilon\alpha}$). For Stratum 2, the secondary compression ratio ranged from 0.008 to 0.016 with a mean value of **0.014**.

The ratio of secondary compression index (C_{α}) to compression index (C_c) tends to be approximately constant for a given soil type, independent of the vertical stress and time elapsed following primary consolidation. This ratio tends to be higher for more plastic, organic materials. This ratio was calculated for each sample and ranged from 0.040 to 0.053. These values are in good agreement with the range proposed by Terzaghi et al. [1996] which suggests this ratio typically ranges from 0.04 to 0.06 for organic clays and silts.

4.3.3 Elastic Compressibility Properties

Settlements of coarse-grained strata are generally attributed to immediate elastic settlements. Consolidation settlement will not occur in coarse-grained strata where high hydraulic conductivity allows soils to drain instantaneously upon loading, not allowing for excess pore water pressures to accumulate.

Drained elastic modulus (E) of coarse-grained strata was estimated from SPT results using the empirical correlation proposed by Kulhawy and Mayne [1990] for normally consolidated sands with fines as follows:

$$\left(\frac{E}{p_{atm}}\right) = 5N_{60} \qquad (2)$$

For Stratum 1, the drained elastic modulus ranged from 14 kips per square foot (ksf) to 1,411 ksf with a mean value of **366 ksf**. For Stratum 4, the drained elastic modulus ranged from 42 ksf to 1,411 ksf with a mean value of **479 ksf**. For Stratum 5, the drained elastic modulus ranged from 141 ksf to 593 ksf with a mean value of **397 ksf**. For Stratum 6, the drained elastic modulus ranged from 705 ksf to 1,411 ksf with a mean value of **1,006 ksf**. Note that these strata also have fine-grained deposits, and these moduli apply only to deposits that were characterized as coarse-grained.

However, it should be noted that for computation of vertical elastic deformations due to placement of fills of large lateral extent, the drained secant constrained modulus (M_{ds}) may be a more useful parameter for coarse-grained soils. This modulus is defined for one-dimensional compression where lateral strains are zero. The drained secant constrained modulus is nonlinear and stress-dependent and would therefore need to be determined specifically for the settlement calculation. For computation of settlements due to placement of footings on coarse-grained soils, it would be prudent to calculate settlements directly from SPT results and footing geometry.

4.4 Shear Strength

Plots and tabulated data used to determine drained and undrained shear strengths of soils are included as Attachment V. Results from SPT results, which are included as Attachment IV, were also used to develop drained shear strengths of coarse-grained soils.

4.4.1 Drained Shear Strength

In soil mechanics, the drained condition refers to loading or unloading of a soil that does not result in a change in pore water pressure, due to either high permeability of the soil or low rate of load application, which allows pore water to flow from the soil as rapidly as it is loaded or unloaded. It also refers to the condition where, given ample time, excess pore water pressures will dissipate from a low permeability soil. Therefore, drained shear strength was defined for both coarse- and fine-grained soils.

For coarse-grained soils where undisturbed samples cannot be obtained for laboratory testing, the effective friction angle (ϕ') was estimated using a correlation to SPT results proposed by Peck et al. [1974] and modified by Carter and Bentley [1991]. For Stratum 1, the effective friction angle ranged from 26.1 degrees to 44.9 degrees with a mean value of **36.0 degrees**. For Stratum 4, the effective friction angle ranged from 26.7 degrees to 44.9 degrees with a mean value of **38.2 degrees**. For Stratum 5, the effective friction angle ranged from 31.5 degrees to 41.3 degrees with a mean value of **37.4 degrees**. For Stratum 6, the effective friction angle ranged from 42.2 degrees to 44.9 degrees with a mean value of **43.9 degrees**. These materials are assumed to have no cohesion.

Effective stress strength parameters of Stratum 2 were evaluated from the results of two CU triaxial tests with pore water pressure measurements (three data points per test). For each test, three samples were consolidated to different effective confining stresses prior to shearing each sample in compression. The effective stress paths were plotted for each sample in terms of the average normal effective stress (p') versus the shear stress (q):

$$p' = \frac{\sigma_1' + \sigma_3'}{2} \tag{3}$$

$$q = \frac{\sigma_1' - \sigma_3'}{2} \tag{4}$$

In Equations 3 and 4, σ_1' and σ_3' are the major and minor principal effective stresses, respectively. For evaluating effective stress strength parameters, a maximum principal stress ratio (σ_1'/σ_3') failure criterion was used. The best-fit line through the failure points was drawn as the failure envelope and the intercept (d') and slope ($\tan\alpha'$) were obtained. When there is significant data scatter, the failure envelope should be drawn such that approximately two-thirds of the test data is above the failure envelope [USACE, 2003]. Equivalent Mohr-Coulomb parameters of cohesion (c') and effective friction angle (ϕ') were calculated using the following equations:

$$\sin\phi' = \tan\alpha' \tag{5}$$

$$c' = \frac{d'}{\cos\phi'} \tag{6}$$

CU triaxial tests were performed on samples from two undisturbed samples from Stratum 2: one from borehole B-17-20 and one from borehole B-24-20. Two distinct failure envelopes were apparent from the different samples. The sample from borehole B-17-20 resulted in c' = **537.4 psf** and ϕ' = **27.9 degrees**. The sample from borehole B-24-20 resulted in c' = **152.2 psf** and ϕ' = **31.6 degrees**. Because of the limited laboratory testing data available, it is recommended to use the results from borehole B-24-20 because it provides lower, more conservative drained shear strength over the stress range of interest for the Site (expected to be less than 5 psi for low permeability cap construction).

Drained shear strength of Stratum 3 was not determined with CU triaxial tests. Stratum 3 is generally similar to Stratum 2 but slightly stiffer and with less organics. Thus, drained shear strength parameters obtained for Stratum 2 may be conservatively used for Stratum 3.

4.4.2 Undrained Shear Strength

In soil mechanics, the undrained condition refers to loading or unloading of a soil that does result in a change in pore water pressure, due to either low permeability of the soil or high rate of load application, which does not allow pore water to flow from the soil as rapidly as it is loaded or unloaded. For coarse-grained high permeability soils, it is usually assumed that soils are permeable enough that excess pore water pressures will dissipate rapidly, and drained shear strengths may be used for the undrained condition. Dynamic loading during earthquakes is the exception where undrained strengths would need to be defined for coarse-grained soils. However, because these properties are not needed for the low permeability cap design, undrained strengths under dynamic loading are not developed herein.

Total stress strength parameters of Stratum 2 were evaluated from the results of twelve UU triaxial tests (one data point per test) and two CU triaxial tests with pore water pressure measurements (three data points per test). Note that one UU triaxial test was performed on Stratum 3 but this sample was evaluated with Stratum 2 due to the similarities of the strata. For evaluating total stress strength parameters, a maximum deviator stress ($\sigma_d = \sigma_1 - \sigma_3$) failure criterion was used. For total stress paths, the maximum deviator stress and maximum principal stress ratio will occur at the same point. However, this will not necessarily be the same point selected for failure for the corresponding effective stress path. Undrained shear strength (s_u) was then calculated as follows:

$$s_u = \frac{\sigma_d}{2} \qquad (7)$$

Undrained shear strengths were plotted against depth to see if any trends were evident. For UU triaxial tests, the depths used for the plot are the depths at which the samples were obtained, since sample are not consolidated during testing. For CU triaxial tests, an equivalent depth was back-calculated from the effective consolidation stress of the test, since samples are consolidated during testing which changes the void ratio from the in situ state. The relationship with undrained shear strength with depth was evaluated using the Jamiolkowski et al. [1985] version of the Stress History and Normalized Soil Engineering Parameters (SHANSEP) equation as follows:

$$\frac{s_u}{\sigma_v'} = 0.23(OCR)^{0.8} \qquad (8)$$

An OCR of 2.0 was considered based on the results of one-dimensional incremental-loading consolidation tests. Equation 8 was also used to back-calculate undrained shear strength from the results of consolidation tests, which were also plotted against sample depth. The plot shows that, despite there being significant scatter in the data, undrained shear strength does appear to increase with depth. The profile plotted with Equation 8 and an OCR of 2.0 plots an undrained strength ratio such that approximately two-thirds of the test data is above the profile, which is appropriate for developing an undrained strength profile [USACE, 2003]. Thus, an undrained shear strength ratio (s_u/σ_v') of 0.40 is recommended.

Undrained shear strength of Stratum 3 was not determined with UU or CU triaxial tests. Stratum 3 is generally similar to Stratum 2 but slightly stiffer and with less organics. Thus, undrained shear strength parameters obtained for Stratum 2 may be conservatively used for Stratum 3.

5 CONCLUSIONS

The following density parameters are recommended:

Stratum	Description	Dry Unit Weight (pcf)	Total Unit Weight (pcf)
1	Fill	108.2	131.2
2	Silty clay and clayey silt, with organics	50.7	91.1
3	Sandy silty clay and clayey silt	104.1	127.6
4	Silty sand and gravel	114.6	138.3
5	Residual soil	121.0	163.8
6	Decomposed rock	127.3	172.4

The following hydraulic conductivity parameters are recommended:

Stratum	Description	Saturated Vertical Hydraulic Conductivity (cm/s)
1	Fill	2.2×10^{-5}
2	Silty clay and clayey silt, with organics	4.7×10^{-7}
3	Sandy silty clay and clayey silt	4.2×10^{-7}
4	Silty sand and gravel	2.2×10^{-5}

The following compressibility parameters are recommended:

Stratum	Description	$C_{\varepsilon c}$	$C_{\varepsilon r}$	$C_{\varepsilon \alpha}$	OCR	Drained Elastic Modulus (ksf)
1	Fill	-	-	-	-	366
2	Silty clay and clayey silt, with organics	0.296	0.036	0.014	2.0	-
3	Sandy silty clay and clayey silt	0.296	0.036	0.014	2.0	-
4	Silty sand and gravel	-	-	-	-	479
5	Residual soil	-	-	-	-	397
6	Decomposed rock	-	-	-	-	1,006

The following shear strength parameters are recommended:

Stratum	Description	ϕ' (degrees)	c' (psf)	s_u/σ'_v
1	Fill	36.0	0	-
2	Silty clay and clayey silt, with organics	31.6	152.2	0.40
3	Sandy silty clay and clayey silt	31.6	152.2	0.40
4	Silty sand and gravel	38.2	0	-
5	Residual soil	37.4	0	-
6	Decomposed rock	43.9	0	-

If future investigations are performed to develop the Site after construction of the low permeability cap, data from those investigations should be used to supplement the data presented herein, and the geotechnical soil properties should be revisited.

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ATTACHMENT I
Index Properties

Density Properties
Strata 1, 4, 5, & 6

Table 4. Relationship Among Relative Density, Penetration Resistance, Dry Unit Weight and Angle of Internal Friction of Cohesionless Soils

Descriptive Relataive Density	Relative Density **	Standard Penetration Resistance N *	Static Cone Resistance q_c	Angle of Internal Friction ϕ	Dry Unit Weight	
	%	blows/ft	tsf or kgf/cm^2	degrees	KN/m^3	
Very Loose	< 15	< 4	< 50	< 30	< 14	
Loose	15 - 35	4 - 10	50 - 100	30 - 32	14 - 16	Stratum 1
Medium Dense	35 - 65	10 - 30	100 - 150	32 - 35	16 - 18	Stratum 4
Dense	65 - 85	30 - 50	150 - 200	35 - 38	18 - 20	Stratum 5
Very Dense	85 - 100	> 50	> 200	> 38	> 20	Stratum 6

* At an effective vertical overburden pressure of 100 kPa

** Freshly deposited, normally consolidated sand

After Mitchell and Katti (1981).

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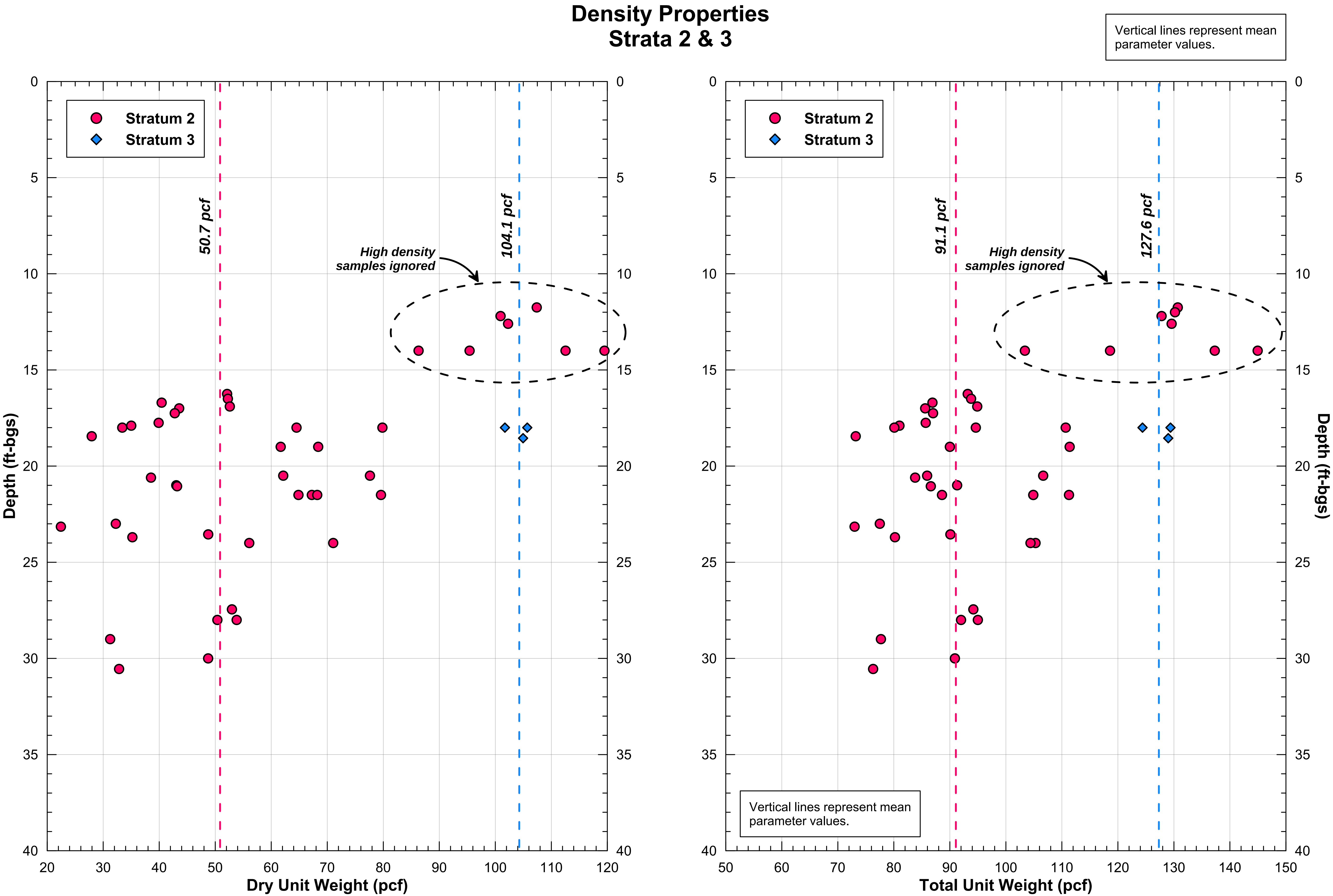

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Summary of Index Tests: Stratum 1

Delaware Valley Works - Pre-Design Investigation

Boring ID	Sample Depth (ft-bgs)	Sample Elevation (ft-msl)	Soil Unit	USCS Group Name	Dry Unit Weight, γ_d (pcf)	Total Unit Weight, γ_t (pcf)	Organic Content (%)	Specific Gravity, G_s	Void Ratio, e_o	Water Content, ω_o (%)	Liquid Limit, LL	Plastic Limit, PL	Plasticity Index, PI	Liquidity Index, LI	Percent Gravel (4.75 - 75 mm) (%)	Percent Sand (0.075 - 4.75 mm) (%)	Percent Fines (< 0.075 mm) (%)	Percent Silt (0.002 - 0.075 mm) (%)	Percent Clay (< 0.002 mm) (%)	Coefficient of Uniformity, C_u	Coefficient of Curvature, C_c
B-04	3.0	+7.8	Stratum 1							22.3											
B-04	5.0	+5.8	Stratum 1							29.3											
B-04	7.0	+3.8	Stratum 1							48.9											
B-11	1.0	+12.6	Stratum 1							9.6					49.0	30.9	20.1				
B-11	6.0	+7.6	Stratum 1							19.4											
B-11	8.0	+5.6	Stratum 1							27.4											
B-13	1.0	+9.9	Stratum 1							2.2					80.6	11.8	7.6			201.1	36.4
B-14	1.0	+9.0	Stratum 1							7.3					66.6	20.6	12.8				
B-15	1.0	+8.5	Stratum 1							24.0					35.7	32.5	31.8				
B-15	6.0	+3.5	Stratum 1							29.7					4.4	29.9	65.7				
B-16-20	8.6	+1.4	Stratum 1	Silty sand with gravel						26.3	NV	NP	NP	NP	27.7	59.3	13.0				
B-17-20	8.0	+1.0	Stratum 1	Silty sand with gravel						29.4	35	NP	NP	NP	23.0	47.7	29.3	13.2	16.1		
B-18-20	4.0	+7.0	Stratum 1	Silty gravel with sand						16.1	NV	NP	NP	NP	49.5	28.8	21.7	12.4	9.3	2433.3	2.6
B-21-20	2.0	+7.0	Stratum 1	Silty sand with gravel						6.2	25	25.0	NP	NP	38.1	40.5	21.4	9.0	12.4		
B-24-20	6.3	+7.7	Stratum 1	Silty sand with gravel						21.8	32	NP	NP	NP	30.6	45.6	23.8	10.1	13.7		

Mean Water Content (%): 21.3

Summary of Index Tests: Stratum 2

Delaware Valley Works - Pre-Design Investigation

Boring ID	Sample Depth (ft-bgs)	Sample Elevation (ft-msl)	Soil Unit	USCS Group Name	Dry Unit Weight, γ_d (pcf)	Total Unit Weight, γ_t (pcf)	Organic Content (%)	Specific Gravity, G_s	Void Ratio, e_o	Water Content, ω_o (%)	Liquid Limit, LL	Plastic Limit, PL	Plasticity Index, PI	Liquidity Index, LI	Percent Gravel (4.75 - 75 mm) (%)	Percent Sand (0.075 - 4.75 mm) (%)	Percent Fines (< 0.075 mm) (%)	Percent Silt (0.002 - 0.075 mm) (%)	Percent Clay (< 0.002 mm) (%)	Coefficient of Uniformity, C_u	Coefficient of Curvature, C_c
B-04	9.0	+1.8	Stratum 2							31.0											
B-04	11.0	-0.2	Stratum 2							33.8											
B-04	16.0	-5.2	Stratum 2							78.2											
B-04	21.0	-10.2	Stratum 2							53.4											
B-04	26.0	-15.2	Stratum 2							79.9											
B-04	30.5	-19.7	Stratum 2							83.6											
B-04	31.3	-20.5	Stratum 2							115.5											
B-04	35.5	-24.7	Stratum 2							22.9											
B-06	17.1	-6.5	Stratum 2							114.6											
B-06	17.65	-7.1	Stratum 2							142.2											
B-06	17.9	-7.3	Stratum 2		35.0	81.0	20.0	2.322	3.143	131.4	201	77	124	0.44							
B-06	18.0	-7.4	Stratum 2		33.4	80.1				139.8											
B-06	18.45	-7.9	Stratum 2		27.9	73.2				161.9					5.6	23.9	70.5	46.1	24.4		
B-11	10.0	+3.6	Stratum 2							23.4											
B-11	11.8	+1.9	Stratum 2		107.4	130.7				21.7											
B-11	12.0	+1.6	Stratum 2			130.2															
B-11	12.0	+1.6	Stratum 2							18.3											
B-11	12.2	+1.4	Stratum 2	Silty clay with sand	100.9	127.8			0.789	26.6	24	17	7	1.37	0.0	22.1	77.9	53.7	24.2		
B-11	12.6	+1.0	Stratum 2		102.3	129.6				26.7											
B-11	14.0	-0.4	Stratum 2							50.3											
B-11	20.6	-7.0	Stratum 2	Elastic silt	38.5	83.8			2.395	117.5	133	57	76	0.80	0.0	4.5	95.5	57.7	37.8		
B-11	21.0	-7.4	Stratum 2		43.0	91.3				112.1											
B-11	21.1	-7.5	Stratum 2		43.2	86.6				100.5											
B-11	24.0	-10.4	Stratum 2							82.7											
B-11	29.0	-15.4	Stratum 2		31.2	77.7				148.7											
B-11	30.0	-16.4	Stratum 2		48.7	90.9				86.5											
B-11	30.55	-17.0	Stratum 2	Elastic silt	32.8	76.3			2.072	132.3	135	61	74	0.96	2.5	11.6	85.9	74.4	11.5	16.4	1.1
B-11	30.8	-17.2	Stratum 2							175.0											
B-12	16.7	-5.7	Stratum 2		40.4	86.9				114.9											
B-12	17.0	-6.0	Stratum 2		43.6	85.6				96.5											
B-12	17.25	-6.3	Stratum 2	Elastic silt	42.8	87.0			2.852	103.4	116	51	65	0.81	0.0	4.0	96.0	62.5	33.5		
B-12	17.5	-6.5	Stratum 2							105.6											
B-12	17.8	-6.8	Stratum 2		39.9	85.7				114.8											
B-12	23.55	-12.6	Stratum 2	Silt	48.8	90.1			1.142	84.8	44	30	14	3.91	0.2	9.4	90.4	65.4	25.0		
B-12	24.0	-13.0	Stratum 2		56.1	105.3				87.8											
B-12	24.0	-13.0	Stratum 2		71.1	104.4				46.9											
B-13	15.6	-4.7	Stratum 2							66.5											
B-13	16.1	-5.2	Stratum 2							50.4											
B-13	16.25	-5.4	Stratum 2	Elastic silt	52.1	93.2		2.575	2.057	78.8	108	53.0	55	0.47	0.0	3.1	96.9	70.0	26.9		

Summary of Index Tests: Stratum 2

Delaware Valley Works - Pre-Design Investigation

Boring ID	Sample Depth (ft-bgs)	Sample Elevation (ft-msl)	Soil Unit	USCS Group Name	Dry Unit Weight, γ_d (pcf)	Total Unit Weight, γ_t (pcf)	Organic Content (%)	Specific Gravity, G_s	Void Ratio, e_o	Water Content, ω_o (%)	Liquid Limit, LL	Plastic Limit, PL	Plasticity Index, PI	Liquidity Index, LI	Percent Gravel (4.75 - 75 mm) (%)	Percent Sand (0.075 - 4.75 mm) (%)	Percent Fines (< 0.075 mm) (%)	Percent Silt (0.002 - 0.075 mm) (%)	Percent Clay (< 0.002 mm) (%)	Coefficient of Uniformity, C_u	Coefficient of Curvature, C_c
B-13	16.5	-5.6	Stratum 2		52.3	93.8				79.5											
B-13	16.9	-6.0	Stratum 2		52.6	94.9	6.4			80.4											
B-13	27.2	-16.3	Stratum 2							91.3											
B-13	27.45	-16.6	Stratum 2	Elastic silt	53.0	94.2		2.465	2.053	77.8	114	49.0	65	0.44	0.0	3.5	96.5	62.2	34.3		
B-13	28.0	-17.1	Stratum 2		53.8	95.0				76.5											
B-13	28.0	-17.1	Stratum 2		50.4	92.0	9.5			82.6											
B-14	22.4	-12.4	Stratum 2							155.2											
B-14	23.0	-13.0	Stratum 2		32.3	77.5				140.3											
B-14	23.15	-13.2	Stratum 2	Silty gravel with sand	22.4	73.0		2.126	2.772	225.3	213	118.0	95	1.13	60.4	22.3	17.3	11.3	6.0	1740.1	174.8
B-14	23.5	-13.5	Stratum 2							116.8											
B-14	23.7	-13.7	Stratum 2		35.2	80.2	22.3			127.8											
B-15	8.0	+1.5	Stratum 2	Lean clay						28.0	41	22	19	0.32	0.0	11.4	88.6				
B-15	10.0	-0.5	Stratum 2	Elastic silt with sand						91.1	142	54	88	0.42	0.0	24.2	75.8				
B-15	12.0	-2.5	Stratum 2							67.8					0.0	39.0	61.0				
B-16-20	20.5	-10.5	Stratum 2	Silty sand	62.1	85.9				38.3	25	NP	NP	NP	8.9	50.4	40.7	33.3	7.4	40.9	0.7
B-17-20	20.5	-11.5	Stratum 2		77.6	106.7				37.4	29	NP	NP	NP							
B-17-20	21.5	-12.5	Stratum 2		79.6	111.3		3.140	1.589	39.8											
B-17-20	21.5	-12.5	Stratum 2		67.2	104.9				56.0											
B-17-20	21.5	-12.5	Stratum 2		68.2	104.9				53.8											
B-17-20	21.5	-12.5	Stratum 2		64.9	88.6				36.6											
B-17-20	31.0	-22.0	Stratum 2				5.0			71.8											
B-18-20	24.0	-13.0	Stratum 2	Silty gravel with sand						28.4	35	NP	NP	NP	53.8	32.8	13.4	7.7	5.7	789.4	1.7
B-19-20	18.0	-7.0	Stratum 2		79.9	110.7	7.3			38.6	NV	NP	NP	NP							
B-19-20	19.0	-8.0	Stratum 2		68.4	111.4				62.9											
B-20-20	28.0	-17.0	Stratum 2							29.6	35	28.0	7	0.23							
B-21-20	18.0	-9.0	Stratum 2		64.5	94.6	5.1			46.7	37	NP	NP	NP							
B-21-20	19.0	-10.0	Stratum 2		61.7	90.0				45.9											
B-22-20	18.0	-6.0	Stratum 2	Sandy silty clay						17.8	28	22.0	6	-0.70	11.0	37.3	51.7	38.6	13.1		
B-24-20	13.0	+1.0	Stratum 2	Sandy silty clay						21.3	21	17.0	4	1.08	4.4	30.8	64.8	28.6	36.2		
B-24-20	14.0	0.0	Stratum 2		119.5	145.0		2.950	0.709	21.3											
B-24-20	14.0	0.0	Stratum 2		95.4	118.6				24.3											
B-24-20	14.0	0.0	Stratum 2		112.5	137.3				22.0											
B-24-20	14.0	0.0	Stratum 2		86.3	103.4				19.8											
B-24-20	31.0	-17.0	Stratum 2	Silty gravel with sand						80.1	NV	NP	NP	NP	58.5	19.7	21.8	14.0	7.8	1927.9	150.7

Notes:

(1) Highlighted unit weight values were all shallower than 15 ft-bgs and had much larger unit weights than other samples. It is possible that these shallower samples may be in a transitional zone from Stratum 1 which is expected to have higher unit weights than Stratum 2. Therefore, these eight samples were ignored when determining mean unit weights of Stratum 2.

Mean Dry Unit Weight (pcf): 50.7

Mean Total Unit Weight (pcf): 91.1

Summary of Index Tests: Stratum 3

Delaware Valley Works - Pre-Design Investigation

Boring ID	Sample Depth (ft-bgs)	Sample Elevation (ft-msl)	Soil Unit	USCS Group Name	Dry Unit Weight, γ_d (pcf)	Total Unit Weight, γ_t (pcf)	Organic Content (%)	Specific Gravity, G_s	Void Ratio, e_o	Water Content, ω_o (%)	Liquid Limit, LL	Plastic Limit, PL	Plasticity Index, PI	Liquidity Index, LI	Percent Gravel (4.75 - 75 mm) (%)	Percent Sand (0.075 - 4.75 mm) (%)	Percent Fines (< 0.075 mm) (%)	Percent Silt (0.002 - 0.075 mm) (%)	Percent Clay (< 0.002 mm) (%)	Coefficient of Uniformity, C_u	Coefficient of Curvature, C_c
B-09	6.0	+7.0	Stratum 3							21.2											
B-09	8.0	+5.0	Stratum 3							21.0											
B-09	10.0	+3.0	Stratum 3							18.9											
B-09	12.0	+1.0	Stratum 3	Lean clay with sand						21.2	29	20	9	0.13	2.1	24.1	73.8				
B-09	15.0	-2.0	Stratum 3	Elastic silt						143.6	217	110	107	0.31	0.1	14.3	85.6				
B-09	17.2	-4.2	Stratum 3							18.6											
B-09	18.0	-5.0	Stratum 3		101.7	124.4				22.3											
B-09	18.0	-5.0	Stratum 3		105.7	129.4				22.4											
B-09	18.2	-5.2	Stratum 3							24.4											
B-09	18.55	-5.6	Stratum 3	Lean clay	105.0	129.0				22.9	29	19	10	0.39	0.0	6.2	93.8	78.2	15.6		
B-09	20.0	-7.0	Stratum 3							23.3											

Mean Dry Unit Weight (pcf): 104.1

Mean Total Unit Weight (pcf): 127.6

Summary of Index Tests: Stratum 4

Delaware Valley Works - Pre-Design Investigation

Boring ID	Sample Depth (ft-bgs)	Sample Elevation (ft-msl)	Soil Unit	USCS Group Name	Dry Unit Weight, γ_d (pcf)	Total Unit Weight, γ_t (pcf)	Organic Content (%)	Specific Gravity, G_s	Void Ratio, e_o	Water Content, ω_o (%)	Liquid Limit, LL	Plastic Limit, PL	Plasticity Index, PI	Liquidity Index, LI	Percent Gravel (4.75 - 75 mm) (%)	Percent Sand (0.075 - 4.75 mm) (%)	Percent Fines (< 0.075 mm) (%)	Percent Silt (0.002 - 0.075 mm) (%)	Percent Clay (< 0.002 mm) (%)	Coefficient of Uniformity, C_u	Coefficient of Curvature, C_c
B-04	36.5	-25.7	Stratum 4							16.2											
B-04	41.0	-30.2	Stratum 4							22.8											
B-04	46.0	-35.2	Stratum 4							14.1											
B-04	51.0	-40.2	Stratum 4							11.7											
B-09	24.0	-11.0	Stratum 4							12.3											
B-11	34.0	-20.4	Stratum 4							13.2					4.3	61.4	34.3				
B-15	16.0	-6.5	Stratum 4							13.2											
B-15	19.0	-9.5	Stratum 4							9.4											
B-15	24.0	-14.5	Stratum 4							18.0											
B-15	29.0	-19.5	Stratum 4							20.5											
B-15	34.0	-24.5	Stratum 4							43.3											
B-15	39.0	-29.5	Stratum 4							52.7											
B-15	43.5	-34.0	Stratum 4							17.6											
B-16-20	25.2	-15.2	Stratum 4	Silty sand with gravel						17.6	21	NP	NP	NP	21.8	33.2	45.0	28.1	16.9		
B-19-20	35.3	-24.3	Stratum 4	Clayey gravel with sand						19.2	23	15.0	8	0.53	38.4	34.5	27.1	10.7	16.4		
B-20-20	35.5	-24.5	Stratum 4	Clayey sand with gravel						21.6	26	16.0	10	0.56	30.2	35.0	34.8	19.5	15.3		
B-20-20	50.0	-39.0	Stratum 4	Silty sand						28.1	NV	NP	NP	NP	1.4	85.6	13.0				

Mean Water Content (%): 20.7

Summary of Index Tests: Stratum 5

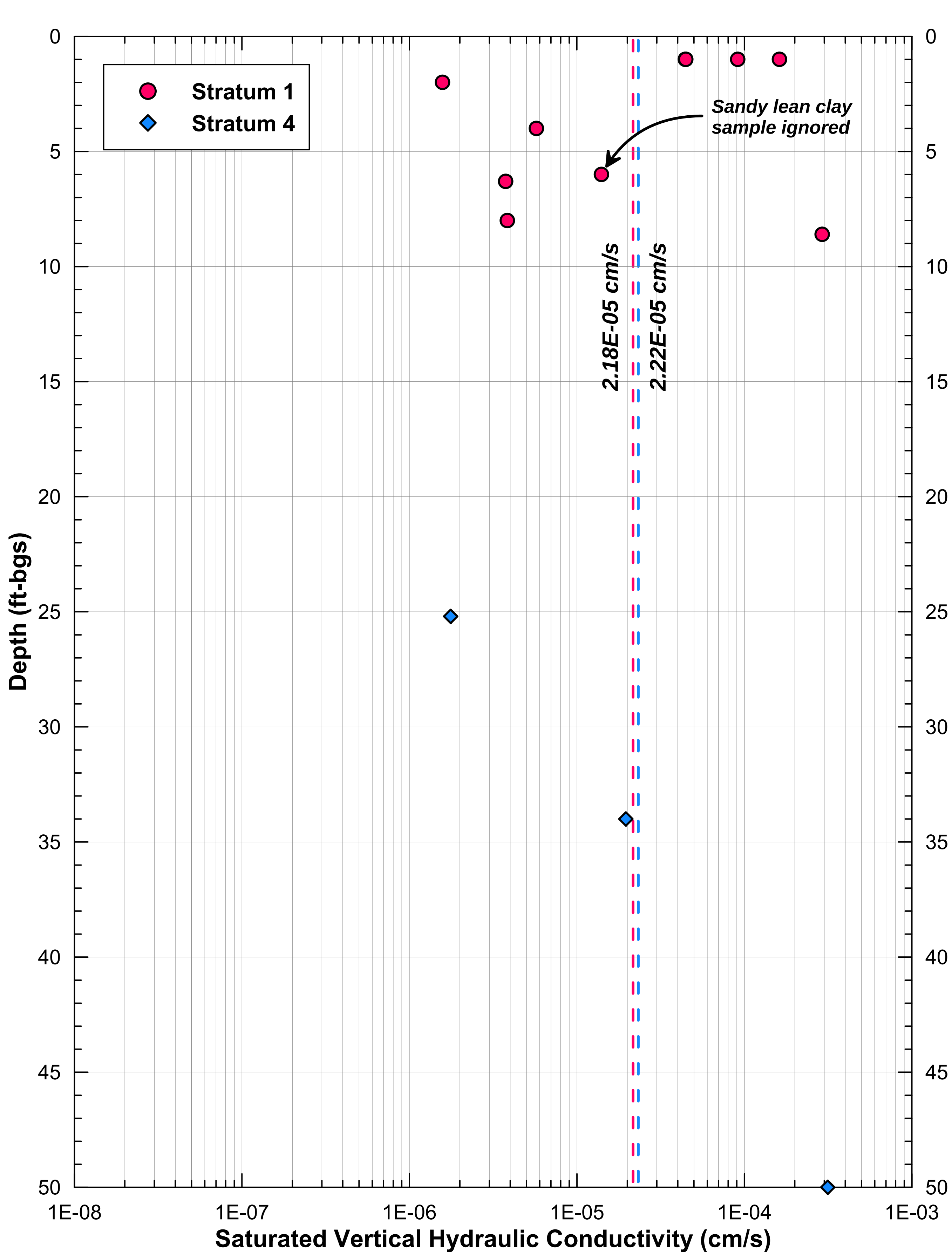
Delaware Valley Works - Pre-Design Investigation

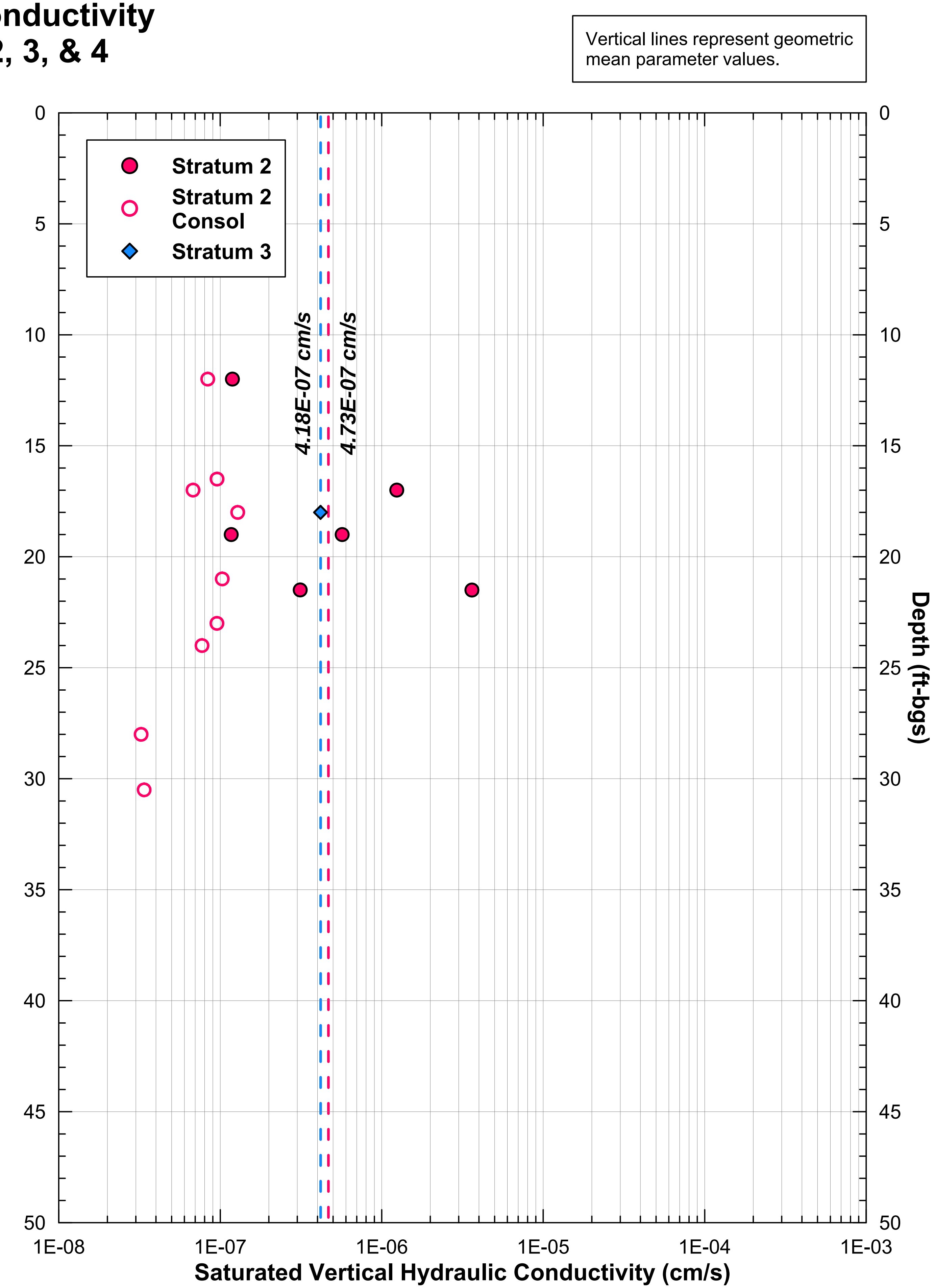
Boring ID	Sample Depth (ft-bgs)	Sample Elevation (ft-msl)	Soil Unit	USCS Group Name	Dry Unit Weight, γ_d (pcf)	Total Unit Weight, γ_t (pcf)	Organic Content (%)	Specific Gravity, G_s	Void Ratio, e_o	Water Content, ω_o (%)	Liquid Limit, LL	Plastic Limit, PL	Plasticity Index, PI	Liquidity Index, LI	Percent Gravel (4.75 - 75 mm) (%)	Percent Sand (0.075 - 4.75 mm) (%)	Percent Fines (< 0.075 mm) (%)	Percent Silt (0.002 - 0.075 mm) (%)	Percent Clay (< 0.002 mm) (%)	Coefficient of Uniformity, C_u	Coefficient of Curvature, C_c
B-09	29.0	-16.0	Stratum 5	Sandy fat clay						42.7	83	33	50	0.19	0.1	35.7	64.2				
B-15	44.5	-35.0	Stratum 5							31.7											
B-15	49.0	-39.5	Stratum 5							31.9					0.0	11.4	88.6				

Mean Water Content (%): 35.4

ATTACHMENT II
Hydraulic Conductivity Properties

Hydraulic Conductivity
Strata 1, 2, 3, & 4





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Permeability Properties
Strata 1, 2, 3, & 4

Table 14.1 Permeability and Drainage Characteristics of Soils*

Coefficient of Permeability k (m/s)

Strata 1 & 4 Strata 2 & 3

	10^{0}	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}	10^{-7}	10^{-8}	10^{-9}	10^{-10}	10^{-11}
Drainage	Good						Poor			Practically Impervious		
Soil types	Clean gravel		Clean sands, clean sand and gravel mixtures			Very fine sands, organic and inorganic silts, mixtures of sand silt and clay, glacial till, stratified clay deposits, etc.				"Impervious" soils, e.g., homogeneous clays below zone of weathering		
					"Impervious" soils modified by effects of vegetation and weathering							

* After Casagrande and Fadum (1940).

Terzaghi, K., Peck, R.B., and Mesri, G. [1996]. "Soil Mechanics in Engineering Practice," Third Edition, John Wiley & Sons, Inc., New York.

Summary of Hydraulic Conductivities from Grain Size Distributions: Stratum 1

Delaware Valley Works - Pre-Design Investigation

Boring ID	Sample Depth (ft-bgs)	Sample Elevation (ft-msl)	Soil Unit	USCS Group Name	Water Content, ω_o (%)	Percent Fines (< 0.075 mm) (%)	Assumed Specific Gravity, G_s	Calculated Void Ratio, e_o	Shape Factor	Calculated Vertical Hydraulic Conductivity, k_v (cm/s)
B-11	1.0	+12.6	Stratum 1	Silty gravel with sand	9.6	20.1	2.68	0.467	7.5 (Medium Angularity)	4.44E-05
B-13	1.0	+9.9	Stratum 1	Poorly graded gravel with silt	2.2	7.6	2.68	0.368	7.5 (Medium Angularity)	1.62E-04
B-14	1.0	+9.0	Stratum 1	Silty gravel with sand	7.3	12.8	2.68	0.436	7.5 (Medium Angularity)	9.13E-05
B-15	1.0	+8.5	Stratum 1	Silty gravel with sand	24.0	31.8	2.68	0.660	7.5 (Medium Angularity)	4.47E-05
B-15	6.0	+3.5	Stratum 1	Sandy lean clay	29.7	65.7	2.68	0.736	7.5 (Medium Angularity)	1.40E-05
B-16-20	8.6	+1.4	Stratum 1	Silty sand with gravel	26.3	13.0	2.68	0.690	7.5 (Medium Angularity)	2.91E-04
B-17-20	8.0	+1.0	Stratum 1	Silty sand with gravel	29.4	29.3	2.68	0.732	7.5 (Medium Angularity)	3.84E-06
B-18-20	4.0	+7.0	Stratum 1	Silty gravel with sand	16.1	21.7	2.68	0.554	7.5 (Medium Angularity)	5.73E-06
B-21-20	2.0	+7.0	Stratum 1	Silty sand with gravel	6.2	21.4	2.68	0.421	7.5 (Medium Angularity)	1.58E-06
B-24-20	6.3	+7.7	Stratum 1	Silty sand with gravel	21.8	23.8	2.68	0.630	7.5 (Medium Angularity)	3.75E-06

Notes:

(1) Vertical hydraulic conductivity calculated using the Kozeny-Carman formula [Carrier, 2003].

(2) Results from B-15 at 3.5 ft-bgs are ignored because the Kozeny-Carman formula is not applicable to clayey soils.

Hydraulic Conductivity Geometric Mean (cm/s): 2.18E-05

Summary of Hydraulic Conductivities from Grain Size Distributions: Stratum 4

Delaware Valley Works - Pre-Design Investigation

Boring ID	Sample Depth (ft-bgs)	Sample Elevation (ft-msl)	Soil Unit	USCS Group Name	Water Content, ω_o (%)	Percent Fines (< 0.075 mm) (%)	Assumed Specific Gravity, G_s	Calculated Void Ratio, e_o	Shape Factor	Calculated Vertical Hydraulic Conductivity, k_v (cm/s)
B-11	34.0	-20.4	Stratum 4	Silty sand	13.2	34.3	2.68	0.515	7.5 (Medium Angularity)	1.96E-05
B-16-20	25.2	-15.2	Stratum 4	Silty sand with gravel	17.6	45.0	2.68	0.574	7.5 (Medium Angularity)	1.76E-06
B-20-20	50.0	-39.0	Stratum 4	Silty sand	28.1	13.0	2.68	0.715	7.5 (Medium Angularity)	3.15E-04

Notes:

(1) Vertical hydraulic conductivity calculated using the Kozeny-Carman formula [Carrier, 2003].

Hydraulic Conductivity Geometric Mean (cm/s): 2.22E-05

Summary of Flexible Wall Permeameter Tests: Stratum 2

Delaware Valley Works - Pre-Design Investigation

Boring ID	Sample Depth (ft-bgs)	Sample Elevation (ft-msl)	Soil Unit	Water Content, ω_o (%)	Total Unit Weight, γ_t (pcf)	Dry Unit Weight, γ_d (pcf)	In Situ Effective Vertical Stress, σ'_{vo} (psf)	Effective Confining Stress, σ'_c (psf)	Average Vertical Hydraulic Conductivity, k_v (cm/s)
B-11	12.0	+1.6	Stratum 2	26.6	127.8	101.0	1,105	720	1.19E-07
B-12	17.0	-6.0	Stratum 2	103.4	87.0	42.8	1,313	864	1.24E-06
B-16-20	21.5	-11.5	Stratum 2	38.3	85.9	62.1	1,713	1,440	3.13E-07
B-17-20	21.5	-12.5	Stratum 2	37.4	106.7	77.6	1,567	1,440	3.62E-06
B-19-20	19.0	-8.0	Stratum 2	38.6	110.7	79.9	1,619	1,440	1.17E-07
B-21-20	19.0	-10.0	Stratum 2	46.7	94.6	64.5	1,674	1,152	5.69E-07

Notes:

(1) Testing performed in accordance with ASTM D5084, Method F.

Hydraulic Conductivity Geometric Mean (cm/s): 4.73E-07

Summary of Flexible Wall Permeameter Tests: Stratum 3

Delaware Valley Works - Pre-Design Investigation

Boring ID	Sample Depth (ft-bgs)	Sample Elevation (ft-msl)	Soil Unit	Water Content, ω_o (%)	Total Unit Weight, γ_t (pcf)	Dry Unit Weight, γ_d (pcf)	In Situ Effective Vertical Stress, σ'_{vo} (psf)	Effective Confining Stress, σ'_c (psf)	Average Vertical Hydraulic Conductivity, k_v (cm/s)
B-09	18.0	-5.0	Stratum 3	22.4	129.4	105.7	1,966	864	4.18E-07

Notes:

(1) Testing performed in accordance with ASTM D5084, Method F.

Hydraulic Conductivity Geometric Mean (cm/s): 4.18E-07

Summary of Incremental Loading Consolidation Tests: Stratum 2

Delaware Valley Works - Pre-Design Investigation

Boring ID	Sample Depth (ft-bgs)	Sample Elevation (ft-msl)	Soil Unit	Water Content, ω_o (%)	Total Unit Weight, γ_t (pcf)	Dry Unit Weight, γ_d (pcf)	Specific Gravity, G_s	Void Ratio, e_o	In Situ Effective Vertical Stress, σ'_{vo} (psf)	Normally Consolidated Coefficient of Consolidation, $c_{v,NC}$ (ft^2/yr)	Over-consolidated Coefficient of Consolidation, $c_{v,OC}$ (ft^2/yr)	Average Vertical Hydraulic Conductivity, k_v (cm/s)
B-06	18.0	-7.4	Stratum 2	131.4	81.0	35.0	2.322	3.143	1,103	7	54	1.28E-07
B-11	12.0	+1.6	Stratum 2	26.7	129.6	102.3	-	0.789	1,075	491	1019	8.37E-08
B-11	21.0	-7.4	Stratum 2	100.5	86.6	43.2	-	2.395	1,350	7	64	1.03E-07
B-11	30.5	-16.9	Stratum 2	86.5	90.9	48.7	-	2.072	1,641	4	18	3.38E-08
B-12	17.0	-6.0	Stratum 2	114.8	85.7	39.9	-	2.852	1,282	5	27	6.79E-08
B-12	24.0	-13.0	Stratum 2	46.9	104.4	71.1	-	1.142	1,496	47	124	7.71E-08
B-13	16.5	-5.6	Stratum 2	80.4	94.9	52.6	2.575	2.057	1,548	26	123	9.56E-08
B-13	28.0	-17.1	Stratum 2	82.6	92.0	50.4	2.465	2.053	1,899	15	61	3.24E-08
B-14	23.0	-13.0	Stratum 2	127.8	80.2	35.2	2.126	2.772	1,138	5	55	9.54E-08
B-17-20	21.5	-12.5	Stratum 2	39.8	111.3	79.6	3.140	1.589	1,536	-	-	-
B-24-20	14.0	0.0	Stratum 2	21.3	145.0	119.5	2.950	0.709	1,246	-	-	-

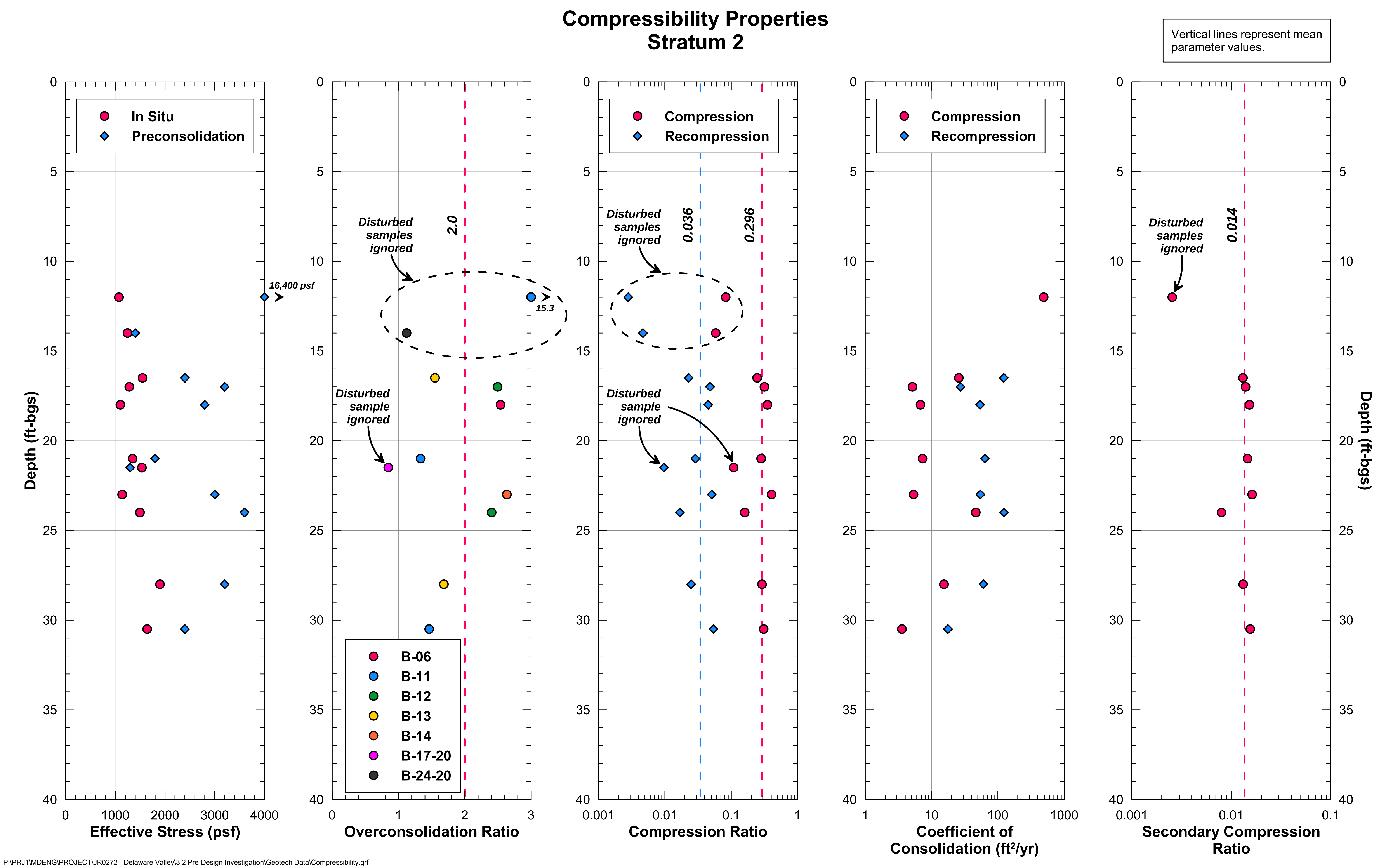
Notes:

(1) Testing performed in accordance with ASTM D2435.

(2) No time-deformation data was provided for B-17-20 (21.5 ft-bgs) and B-24-20 (14.0 ft-bgs) and therefore hydraulic conductivity could not be calculated for these samples.

Hydraulic Conductivity Geometric Mean (cm/s): 7.29E-08

ATTACHMENT III
Compressibility Properties



Compressibility Properties
Stratum 2
Vertical lines represent mean parameter values.
In Situ
Preconsolidation
Compression
Recompression
Disturbed samples ignored
Disturbed sample ignored
16,400 psf
15.3
2.0
0.036
0.296
0.014
B-06
B-11
B-12
B-13
B-14
B-17-20
B-24-20
Depth (ft-bgs)
Effective Stress (psf)
Overconsolidation Ratio
Compression Ratio
Coefficient of Consolidation (ft²/yr)
Secondary Compression Ratio
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Summary of Incremental Loading Consolidation Tests: Stratum 2

Delaware Valley Works - Pre-Design Investigation

Boring ID	Sample Depth (ft-bgs)	Sample Elevation (ft-msl)	Soil Unit	Water Content, w_o (%)	Total Unit Weight, γ_t (pcf)	Dry Unit Weight, γ_d (pcf)	Specific Gravity, G_s	Void Ratio, e_o	In Situ Effective Vertical Stress, σ'_{vo} (psf)	Pre-consolidation Stress, σ'_p (psf)	Over-consolidation Ratio, OCR	Compression Index, C_c	Compression Ratio, $C_{\varepsilon c}$	Re-compression Index, C_r	Re-compression Ratio, $C_{\varepsilon r}$	Secondary Compression Index, C_α	Secondary Compression Ratio, $C_{\varepsilon\alpha}$	C_α / C_c
B-06	18.0	-7.4	Stratum 2	131.4	81.0	35.0	2.322	3.143	1,103	2,800	2.5	1.458	0.352	0.186	0.045	0.063	0.015	0.043
B-11	12.0	+1.6	Stratum 2	26.7	129.6	102.3	-	0.789	1,075	16,400	15.3	0.148	0.083	0.005	0.003	0.005	0.003	0.031
B-11	21.0	-7.4	Stratum 2	100.5	86.6	43.2	-	2.395	1,350	1,800	1.3	0.961	0.283	0.098	0.029	0.049	0.015	0.051
B-11	30.5	-16.9	Stratum 2	86.5	90.9	48.7	-	2.072	1,641	2,400	1.5	0.949	0.309	0.166	0.054	0.048	0.016	0.050
B-12	17.0	-6.0	Stratum 2	114.8	85.7	39.9	-	2.852	1,282	3,200	2.5	1.221	0.317	0.185	0.048	0.054	0.014	0.044
B-12	24.0	-13.0	Stratum 2	46.9	104.4	71.1	-	1.142	1,496	3,600	2.4	0.343	0.160	0.036	0.017	0.017	0.008	0.050
B-13	16.5	-5.6	Stratum 2	80.4	94.9	52.6	2.575	2.057	1,548	2,400	1.6	0.752	0.246	0.070	0.023	0.040	0.013	0.053
B-13	28.0	-17.1	Stratum 2	82.6	92.0	50.4	2.465	2.053	1,899	3,200	1.7	0.889	0.291	0.076	0.025	0.040	0.013	0.045
B-14	23.0	-13.0	Stratum 2	127.8	80.2	35.2	2.126	2.772	1,138	3,000	2.6	1.539	0.408	0.192	0.051	0.061	0.016	0.040
B-17-20	21.5	-12.5	Stratum 2	39.8	111.3	79.6	3.140	1.589	1,536	1,300	0.8	0.282	0.109	0.025	0.010	-	-	-
B-24-20	14.0	0.0	Stratum 2	21.3	145.0	119.5	2.950	0.709	1,246	1,400	1.1	0.100	0.059	0.008	0.005	-	-	-

Notes:

(1) Testing performed in accordance with ASTM D2435.

(2) Results from B-11 (12.0 ft-bgs), B-17-20 (21.5 ft-bgs), and B-24-20 (14.0 ft-bgs) are ignored because the consolidation curves had no clearly defined point of maximum curvature. Samples may have been subjected to significant sample disturbance or contained a larger-than-expected coarse-grained content. Compressibility parameters from these tests are generally smaller than other tests. Thus, ignoring these results is considered conservative.

Mean Overconsolidation Ratio: 2.0

Mean Compression Index: 1.014

Mean Compression Ratio: 0.296

Mean Recompression Index: 0.126

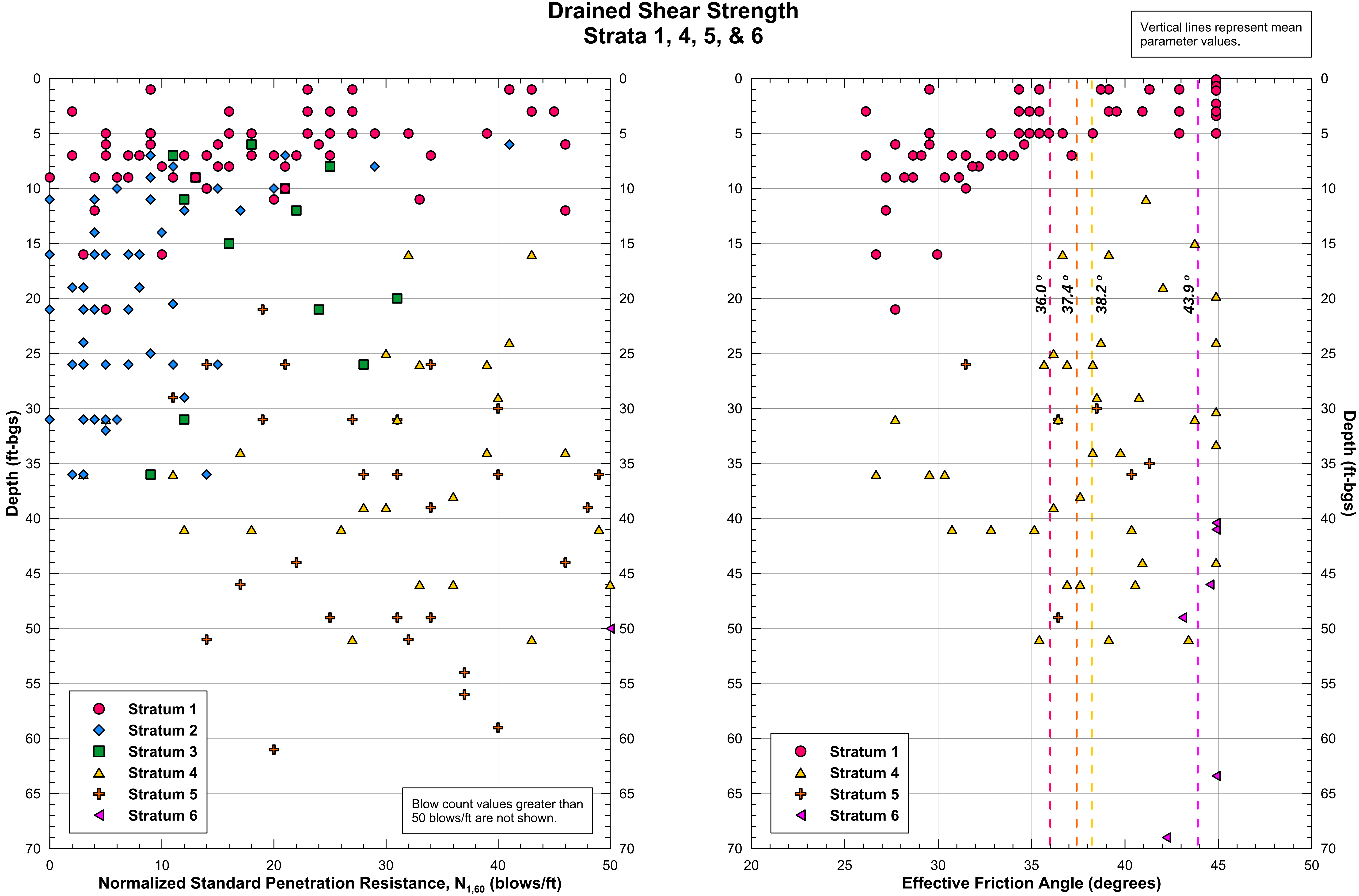
Mean Recompression Ratio: 0.036

Mean Secondary Compression Index: 0.047

Mean Secondary Compression Ratio: 0.014

ATTACHMENT IV
Standard Penetration Tests

Drained Shear Strength
Strata 1, 4, 5, & 6



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Summary of Standard Penetration Test Results: Stratum 1

Delaware Valley Works - Pre-Design Investigation

Boring ID	Test Depth (ft-bgs)	Test Elevation (ft-msl)	Soil Unit	Hammer Energy Transfer Ratio [1] (%)	N_m (blows/ft)	N_{60} (blows/ft)	Effective Vertical Stress, σ'_{vo} (psf)	C_N	$N_{1,60}$ (blows/ft)	Friction Angle, ϕ' [2] (degrees)	Elastic Modulus, Sands with Fines, E [3] (ksf)
B-01	1.0	+9.6	Stratum 1	80.0	10	13	130.0	1.70	23	34.3	141
B-01	3.0	+7.6	Stratum 1	80.0	11	15	390.0	1.70	25	34.9	155
B-01	5.0	+5.6	Stratum 1	80.0	12	16	625.0	1.70	27	35.4	169
B-02	1.0	+8.5	Stratum 1	80.0	18	24	130.0	1.70	41	38.7	254
B-02	3.0	+6.5	Stratum 1	80.0	12	16	390.0	1.70	27	35.4	169
B-02	5.0	+4.5	Stratum 1	80.0	4	5	587.6	1.70	9	29.5	56
B-03	1.0	+9.5	Stratum 1	80.0	28	37	130.0	1.70	63	42.9	395
B-03	3.0	+7.5	Stratum 1	80.0	10	13	390.0	1.70	23	34.3	141
B-03	5.0	+5.5	Stratum 1	80.0	11	15	650.0	1.70	25	34.9	155
B-03	7.0	+3.5	Stratum 1	80.0	7	9	878.8	1.55	14	31.5	99
B-03	9.0	+1.5	Stratum 1	80.0	7	9	1,014.0	1.44	13	31.1	99
B-03	11.0	-0.5	Stratum 1	80.0	18	24	1,149.2	1.36	33		
B-04	3.0	+7.8	Stratum 1	80.0	19	25	390.0	1.70	43	39.1	268
B-04	5.0	+5.8	Stratum 1	80.0	4	5	537.7	1.70	9	29.5	56
B-04	7.0	+3.8	Stratum 1	80.0	15	20	672.9	1.70	34	37.1	212
B-05	1.0	+10.0	Stratum 1	80.0	24	32	130.0	1.70	54	41.3	339
B-05	3.0	+8.0	Stratum 1	80.0	28	37	390.0	1.70	63	42.9	395
B-05	5.0	+6.0	Stratum 1	80.0	7	9	550.2	1.70	16		
B-05	7.0	+4.0	Stratum 1	80.0	11	15	685.4	1.70	25		
B-05	9.0	+2.0	Stratum 1	80.0	6	8	820.6	1.61	13		
B-05	11.0	0.0	Stratum 1	80.0	10	13	955.8	1.49	20		
B-06	2.3	+8.3	Stratum 1	80.0	R	133	299.0	1.70	227	44.9	1,411
B-06	5.0	+5.6	Stratum 1	80.0	8	11	593.8	1.70	18	32.8	113
B-06	7.0	+3.6	Stratum 1	80.0	3	4	729.0	1.70	7	28.7	42
B-07	0.3	+10.8	Stratum 1	80.0	R	133	39.0	1.70	227	44.9	1,411
B-07	3.0	+8.1	Stratum 1	80.0	7	9	390.0	1.70	16		
B-07	5.0	+6.1	Stratum 1	80.0	2	3	556.4	1.70	5		
B-07	7.0	+4.1	Stratum 1	80.0	2	3	691.6	1.70	5		
B-07	9.0	+2.1	Stratum 1	80.0	WOH	0	826.8	1.60	0		
B-08	0.3	+11.2	Stratum 1	80.0	R	133	39.0	1.70	227	44.9	1,411
B-08	2.3	+9.2	Stratum 1	80.0	R	133	299.0	1.70	227	44.9	1,411
B-08	5.0	+6.5	Stratum 1	80.0	14	19	650.0	1.70	32	36.7	198
B-10	6.0	+6.0	Stratum 1	80.0	7	9	780.0	1.65	15		
B-10	8.0	+4.0	Stratum 1	80.0	5	7	1,040.0	1.43	10		
B-10	10.0	+2.0	Stratum 1	80.0	8	11	1,300.0	1.28	14		
B-10	12.0	0.0	Stratum 1	80.0	33	44	1,466.4	1.20	53		
B-11	6.0	+7.6	Stratum 1	80.0	11	15	780.0	1.65	24	34.6	155
B-11	8.0	+5.6	Stratum 1	80.0	8	11	915.2	1.52	16	32.2	113
B-12	6.0	+5.0	Stratum 1	80.0	4	5	686.4	1.70	9	29.5	56
B-12	8.0	+3.0	Stratum 1	80.0	7	9	821.6	1.60	15	31.8	99
B-12	10.0	+1.0	Stratum 1	80.0	7	9	956.8	1.49	14	31.5	99
B-12	12.0	-1.0	Stratum 1	80.0	2	3	1,092.0	1.39	4	27.2	28
B-13	6.0	+4.9	Stratum 1	80.0	21	28	780.0	1.65	46		
B-13	8.0	+2.9	Stratum 1	80.0	11	15	1,040.0	1.43	21		
B-13	10.0	+0.9	Stratum 1	80.0	12	16	1,237.6	1.31	21		

Summary of Standard Penetration Test Results: Stratum 1

Delaware Valley Works - Pre-Design Investigation

Boring ID	Test Depth (ft-bgs)	Test Elevation (ft-msl)	Soil Unit	Hammer Energy Transfer Ratio [1] (%)	N_m (blows/ft)	N_{60} (blows/ft)	Effective Vertical Stress, σ'_{vo} (psf)	C_N	$N_{1,60}$ (blows/ft)	Friction Angle, ϕ' [2] (degrees)	Elastic Modulus, Sands with Fines, E [3] (ksf)
B-13	12.0	-1.1	Stratum 1	80.0	28	37	1,372.8	1.24	46		
B-15	6.0	+3.5	Stratum 1	80.0	2	3	655.2	1.70	5	27.7	28
B-16-20	0.7	+9.3	Stratum 1	80.0	R	133	91.0	1.70	227	44.9	1,411
B-16-20	3.0	+7.0	Stratum 1	80.0	62	83	390.0	1.70	141	44.9	875
B-16-20	5.0	+5.0	Stratum 1	80.0	28	37	650.0	1.70	63	42.9	395
B-16-20	7.0	+3.0	Stratum 1	80.0	10	13	910.0	1.52	20	33.5	141
B-16-20	9.0	+1.0	Stratum 1	80.0	7	9	1,045.2	1.42	13	31.1	99
B-17-20	1.0	+8.0	Stratum 1	80.0	4	5	130.0	1.70	9	29.5	56
B-17-20	3.0	+6.0	Stratum 1	80.0	1	1	390.0	1.70	2	26.1	14
B-17-20	5.0	+4.0	Stratum 1	80.0	4	5	650.0	1.70	9	29.5	56
B-17-20	7.0	+2.0	Stratum 1	80.0	1	1	785.2	1.64	2	26.1	14
B-17-20	9.0	0.0	Stratum 1	80.0	2	3	920.4	1.52	4	27.2	28
B-18-20	1.0	+10.0	Stratum 1	80.0	12	16	130.0	1.70	27	35.4	169
B-18-20	3.0	+8.0	Stratum 1	80.0	23	31	390.0	1.70	52	40.9	324
B-18-20	5.0	+6.0	Stratum 1	80.0	17	23	650.0	1.70	39	38.3	240
B-18-20	7.0	+4.0	Stratum 1	80.0	9	12	910.0	1.52	18	32.8	127
B-18-20	9.0	+2.0	Stratum 1	80.0	4	5	1,170.0	1.34	7	28.7	56
B-18-20	16.0	-5.0	Stratum 1	80.0	2	3	1,643.2	1.13	3	26.7	28
B-19-20	1.0	+10.0	Stratum 1	80.0	19	25	130.0	1.70	43	39.1	268
B-19-20	3.4	+7.6	Stratum 1	80.0	R	133	442.0	1.70	227	44.9	1,411
B-19-20	5.0	+6.0	Stratum 1	80.0	10	13	650.0	1.70	23	34.3	141
B-19-20	7.0	+4.0	Stratum 1	80.0	6	8	910.0	1.52	12	30.7	85
B-19-20	9.0	+2.0	Stratum 1	80.0	3	4	1,045.2	1.42	6	28.2	42
B-20-20	0.1	+10.9	Stratum 1	80.0	R	133	13.0	1.70	227	44.9	1,411
B-20-20	3.0	+8.0	Stratum 1	80.0	20	27	390.0	1.70	45	39.6	282
B-20-20	5.0	+6.0	Stratum 1	80.0	33	44	650.0	1.70	75	44.9	466
B-20-20	7.0	+4.0	Stratum 1	80.0	4	5	910.0	1.52	8	29.1	56
B-20-20	9.0	+2.0	Stratum 1	80.0	7	9	1,170.0	1.34	13	31.1	99
B-20-20	16.0	-5.0	Stratum 1	80.0	7	9	1,986.4	1.03	10	29.9	99
B-20-20	21.0	-10.0	Stratum 1	80.0	4	5	2,324.4	0.95	5	27.7	56
B-21-20	1.0	+8.0	Stratum 1	80.0	57	76	130.0	1.70	129	44.9	804
B-21-20	3.0	+6.0	Stratum 1	80.0	53	71	390.0	1.70	120	44.9	748
B-21-20	5.0	+4.0	Stratum 1	80.0	13	17	650.0	1.70	29	35.9	183
B-21-20	7.0	+2.0	Stratum 1	80.0	7	9	910.0	1.52	14	31.5	99
B-21-20	9.0	0.0	Stratum 1	80.0	6	8	1,107.6	1.38	11	30.4	85
B-22-20	0.7	+11.3	Stratum 1	80.0	R	133	91.0	1.70	227	44.9	1,411
B-22-20	3.0	+9.0	Stratum 1	80.0	38	51	390.0	1.70	86	44.9	536
B-22-20	5.0	+7.0	Stratum 1	80.0	53	71	650.0	1.70	120	44.9	748
B-23-20	1.1	+10.9	Stratum 1	80.0	R	133	143.0	1.70	227	44.9	1,411
B-24-20	1.0	+13.0	Stratum 1	80.0	18	24	130.0	1.70	41	38.7	254
B-24-20	3.0	+11.0	Stratum 1	80.0	38	51	390.0	1.70	86	44.9	536

Summary of Standard Penetration Test Results: Stratum 1

Delaware Valley Works - Pre-Design Investigation

Boring ID	Test Depth (ft-bgs)	Test Elevation (ft-msl)	Soil Unit	Hammer Energy Transfer Ratio [1] (%)	N_m (blows/ft)	N_{60} (blows/ft)	Effective Vertical Stress, σ'_{vo} (psf)	C_N	$N_{1,60}$ (blows/ft)	Friction Angle, ϕ' [2] (degrees)	Elastic Modulus, Sands with Fines, E [3] (ksf)
B-24-20	5.0	+9.0	Stratum 1	80.0	61	81	650.0	1.70	138	44.9	861
B-24-20	7.0	+7.0	Stratum 1	80.0	11	15	910.0	1.52	22	34.0	155

Acronyms:

R = Refusal

WOH = Weight of Hammer

Mean Friction Angle (degrees): 36.0

Notes:

(1) Hammer energy transfer ratio is assumed to be 80.0 percent for tests performed with automatic trip hammer.

Mean Elastic Modulus (ksf): 366

(2) Correlation to friction angle from Peck et al. [1974], modified by Carter and Bentley [1991]. Correlation is only valid for coarse-grained soils.

(3) Correlation to elastic modulus from Kulhawy and Mayne [1990] for normally consolidated sands with fines.

Summary of Standard Penetration Test Results: Stratum 2

Delaware Valley Works - Pre-Design Investigation

Boring ID	Test Depth (ft-bgs)	Test Elevation (ft-msl)	Soil Unit	Hammer Energy Transfer Ratio [1] (%)	N_m (blows/ft)	N_{60} (blows/ft)	Effective Vertical Stress, σ'_{vo} (psf)	C_N	$N_{1,60}$ (blows/ft)	Friction Angle, ϕ' [2] (degrees)	Elastic Modulus, Sands with Fines, E [3] (ksf)
B-01	7.0	+3.6	Stratum 2	80.0	4	5	723.2	1.70	9		
B-01	9.0	+1.6	Stratum 2	80.0	WOH	0	784.4	1.64	0		
B-01	11.0	-0.4	Stratum 2	80.0	WOH	0	845.6	1.58	0		
B-01	16.0	-5.4	Stratum 2	80.0	WOH	0	998.6	1.46	0		
B-01	21.0	-10.4	Stratum 2	80.0	3	4	1,151.6	1.36	5		
B-01	26.0	-15.4	Stratum 2	80.0	9	12	1,304.6	1.27	15		
B-03	16.0	-5.5	Stratum 2	80.0	WOH	0	1,394.7	1.23	0		
B-04	9.0	+1.8	Stratum 2	80.0	2	3	771.1	1.66	4		
B-04	11.0	-0.2	Stratum 2	80.0	4	5	832.3	1.59	9		
B-04	16.0	-5.2	Stratum 2	80.0	WOH	0	985.3	1.47	0		
B-04	21.0	-10.2	Stratum 2	80.0	WOH	0	1,138.3	1.36	0		
B-04	26.0	-15.2	Stratum 2	80.0	2	3	1,291.3	1.28	3		
B-04	31.0	-20.2	Stratum 2	80.0	WOH	0	1,444.3	1.21	0		
B-04	36.0	-25.2	Stratum 2	80.0	9	12	1,597.3	1.15	14		
B-05	16.0	-5.0	Stratum 2	80.0	2	3	1,201.3	1.33	4		
B-05	21.0	-10.0	Stratum 2	80.0	4	5	1,354.3	1.25	7		
B-06	9.0	+1.6	Stratum 2	80.0	2	3	827.2	1.60	4		
B-06	11.0	-0.4	Stratum 2	80.0	2	3	888.4	1.54	4		
B-06	16.0	-5.4	Stratum 2	80.0	WOH	0	1,041.4	1.43	0		
B-06	21.0	-10.4	Stratum 2	80.0	2	3	1,194.4	1.33	4		
B-08	7.0	+4.5	Stratum 2	80.0	4	5	873.0	1.56	8		
B-08	11.0	+0.5	Stratum 2	80.0	2	3	1,182.6	1.34	4		
B-08	16.0	-4.5	Stratum 2	80.0	2	3	1,335.6	1.26	3		
B-08	21.0	-9.5	Stratum 2	80.0	3	4	1,488.6	1.19	5		
B-11	10.0	+3.6	Stratum 2	80.0	3	4	1,013.4	1.45	6		
B-11	14.0	-0.4	Stratum 2	80.0	2	3	1,135.8	1.36	4		
B-11	19.0	-5.4	Stratum 2	80.0	1	1	1,288.8	1.28	2		
B-11	24.0	-10.4	Stratum 2	80.0	2	3	1,441.8	1.21	3		
B-11	29.0	-15.4	Stratum 2	80.0	8	11	1,594.8	1.15	12		
B-12	14.0	-3.0	Stratum 2	80.0	2	3	1,190.2	1.33	4		
B-12	19.0	-8.0	Stratum 2	80.0	2	3	1,343.2	1.26	3		
B-13	14.0	-3.1	Stratum 2	80.0	6	8	1,471.0	1.20	10		
B-13	19.0	-8.1	Stratum 2	80.0	5	7	1,624.0	1.14	8		
B-13	26.0	-15.1	Stratum 2	80.0	5	7	1,838.2	1.07	7		
B-13	32.0	-21.1	Stratum 2	80.0	4	5	2,021.8	1.02	5		
B-14	6.0	+4.0	Stratum 2	80.0	18	24	618.2	1.70	41		
B-14	8.0	+2.0	Stratum 2	80.0	13	17	679.4	1.70	29		
B-14	10.0	0.0	Stratum 2	80.0	9	12	740.6	1.69	20		
B-14	12.0	-2.0	Stratum 2	80.0	8	11	801.8	1.62	17		
B-14	16.0	-6.0	Stratum 2	80.0	4	5	924.2	1.51	8		
B-14	20.5	-10.5	Stratum 2	80.0	6	8	1,061.9	1.41	11		
B-14	25.0	-15.0	Stratum 2	80.0	5	7	1,199.6	1.33	9		
B-15	8.0	+1.5	Stratum 2	80.0	5	7	753.4	1.68	11		
B-15	10.0	-0.5	Stratum 2	80.0	7	9	814.6	1.61	15		
B-15	12.0	-2.5	Stratum 2	80.0	6	8	875.8	1.55	12		

Summary of Standard Penetration Test Results: Stratum 2

Delaware Valley Works - Pre-Design Investigation

Boring ID	Test Depth (ft-bgs)	Test Elevation (ft-msl)	Soil Unit	Hammer Energy Transfer Ratio [1] (%)	N_m (blows/ft)	N_{60} (blows/ft)	Effective Vertical Stress, σ'_{vo} (psf)	C_N	$N_{1,60}$ (blows/ft)	Friction Angle, ϕ' [2] (degrees)	Elastic Modulus, Sands with Fines, E [3] (ksf)
B-16-20	16.0	-6.0	Stratum 2	80.0	5	7	1,488.8	1.19	8		
B-17-20	16.0	-7.0	Stratum 2	80.0	3	4	1,367.7	1.24	5		
B-17-20	26.0	-17.0	Stratum 2	80.0	2	3	1,673.7	1.12	3		
B-17-20	31.0	-22.0	Stratum 2	80.0	2	3	1,826.7	1.08	3		
B-17-20	36.0	-27.0	Stratum 2	80.0	2	3	1,979.7	1.03	3		
B-18-20	21.0	-10.0	Stratum 2	80.0	2	3	1,966.4	1.04	3		
B-18-20	31.0	-20.0	Stratum 2	80.0	2	3	2,272.4	0.97	3		
B-18-20	36.0	-25.0	Stratum 2	80.0	2	3	2,425.4	0.93	2		
B-19-20	16.0	-5.0	Stratum 2	80.0	2	3	1,496.2	1.19	3		
B-19-20	21.0	-10.0	Stratum 2	80.0	2	3	1,649.2	1.13	3		
B-19-20	26.0	-15.0	Stratum 2	80.0	2	3	1,802.2	1.08	3		
B-19-20	31.0	-20.0	Stratum 2	80.0	3	4	1,955.2	1.04	4		
B-20-20	26.0	-15.0	Stratum 2	80.0	2	3	2,647.6	0.89	2		
B-20-20	31.0	-20.0	Stratum 2	80.0	4	5	2,800.6	0.87	5		
B-21-20	16.0	-7.0	Stratum 2	80.0	2	3	1,551.2	1.17	3		
B-22-20	7.0	+5.0	Stratum 2	80.0	10	13	895.2	1.54	21		
B-22-20	9.0	+3.0	Stratum 2	80.0	5	7	1,081.2	1.40	9		
B-22-20	16.0	-4.0	Stratum 2	80.0	5	7	1,694.8	1.12	7		
B-22-20	21.0	-9.0	Stratum 2	80.0	5	7	1,847.8	1.07	7		
B-22-20	26.0	-14.0	Stratum 2	80.0	8	11	2,000.8	1.03	11		
B-24-20	9.0	+5.0	Stratum 2	80.0	4	5	1,093.0	1.39	7		
B-24-20	16.0	-2.0	Stratum 2	80.0	2	3	1,307.2	1.27	3		
B-24-20	21.0	-7.0	Stratum 2	80.0	2	3	1,460.2	1.20	3		
B-24-20	26.0	-12.0	Stratum 2	80.0	3	4	1,613.2	1.15	5		
B-24-20	31.0	-17.0	Stratum 2	80.0	4	5	1,766.2	1.09	6		
B-24-20	36.0	-22.0	Stratum 2	80.0	10	13	1,919.2	1.05	14		

Acronyms:

R = Refusal

WOH = Weight of Hammer

Notes:

(1) Hammer energy transfer ratio is assumed to be 80.0 percent for tests performed with automatic trip hammer.

(2) Correlation to friction angle from Peck et al. [1974], modified by Carter and Bentley [1991]. Correlation is only valid for coarse-grained soils.

(3) Correlation to elastic modulus from Kulhawy and Mayne [1990] for normally consolidated sands with fines.

Summary of Standard Penetration Test Results: Stratum 3

Delaware Valley Works - Pre-Design Investigation

Boring ID	Test Depth (ft-bgs)	Test Elevation (ft-msl)	Soil Unit	Hammer Energy Transfer Ratio [1] (%)	N_m (blows/ft)	N_{60} (blows/ft)	Effective Vertical Stress, σ'_{vo} (psf)	C_N	$N_{1,60}$ (blows/ft)	Friction Angle, ϕ' [2] (degrees)	Elastic Modulus, Sands with Fines, E [3] (ksf)
B-02	7.0	+2.5	Stratum 3	80.0	5	7	720.4	1.70	11		
B-02	9.0	+0.5	Stratum 3	80.0	6	8	850.8	1.58	13		
B-02	11.0	-1.5	Stratum 3	80.0	6	8	981.2	1.47	12		
B-03	21.0	-10.5	Stratum 3	80.0	16	21	1,634.2	1.14	24		
B-08	26.0	-14.5	Stratum 3	80.0	19	25	1,728.1	1.11	28		
B-08	31.0	-19.5	Stratum 3	80.0	9	12	2,054.1	1.02	12		
B-08	36.0	-24.5	Stratum 3	80.0	7	9	2,380.1	0.94	9		
B-09	6.0	+7.0	Stratum 3	80.0	8	11	775.2	1.65	18		
B-09	8.0	+5.0	Stratum 3	80.0	13	17	1,030.4	1.43	25		
B-09	10.0	+3.0	Stratum 3	80.0	12	16	1,285.6	1.28	21		
B-09	12.0	+1.0	Stratum 3	80.0	14	19	1,509.6	1.18	22		
B-09	15.0	-2.0	Stratum 3	80.0	11	15	1,705.2	1.11	16		
B-09	20.0	-7.0	Stratum 3	80.0	23	31	2,031.2	1.02	31		

Acronyms:

R = Refusal

WOH = Weight of Hammer

Notes:

(1) Hammer energy transfer ratio is assumed to be 80.0 percent for tests performed with automatic trip hammer.

(2) Correlation to friction angle from Peck et al. [1974], modified by Carter and Bentley [1991]. Correlation is only valid for coarse-grained soils.

(3) Correlation to elastic modulus from Kulhawy and Mayne [1990] for normally consolidated sands with fines.

Summary of Standard Penetration Test Results: Stratum 4

Delaware Valley Works - Pre-Design Investigation

Boring ID	Test Depth (ft-bgs)	Test Elevation (ft-msl)	Soil Unit	Hammer Energy Transfer Ratio [1] (%)	N_m (blows/ft)	N_{60} (blows/ft)	Effective Vertical Stress, σ'_{vo} (psf)	C_N	$N_{1,60}$ (blows/ft)	Friction Angle, ϕ' [2] (degrees)	Elastic Modulus, Sands with Fines, E [3] (ksf)
B-01	31.0	-20.4	Stratum 4	80.0	20	27	1,537.6	1.17	31	36.4	282
B-01	36.0	-25.4	Stratum 4	80.0	6	8	1,850.6	1.07	9	29.5	85
B-01	41.0	-30.4	Stratum 4	80.0	14	19	2,163.6	0.99	18	32.8	198
B-01	46.0	-35.4	Stratum 4	80.0	29	39	2,476.6	0.92	36	37.6	409
B-01	51.0	-40.4	Stratum 4	80.0	23	31	2,789.6	0.87	27	35.4	324
B-02	15.0	-5.5	Stratum 4	80.0	39	52	1,242.0	1.31	68	43.7	550
B-02	19.8	-10.3	Stratum 4	80.0	R	133	1,542.5	1.17	156	44.9	1,411
B-02	25.0	-15.5	Stratum 4	80.0	21	28	1,868.0	1.06	30	36.2	296
B-04	41.0	-30.2	Stratum 4	80.0	35	47	1,894.3	1.06	49	40.4	494
B-04	46.0	-35.2	Stratum 4	80.0	38	51	2,207.3	0.98	50	40.6	536
B-04	51.0	-40.2	Stratum 4	80.0	35	47	2,520.3	0.92	43	39.1	494
B-06	26.0	-15.4	Stratum 4	80.0	20	27	1,347.4	1.25	33	36.9	282
B-06	30.3	-19.7	Stratum 4	80.0	R	133	1,616.6	1.14	153	44.9	1,411
B-07	11.0	+0.1	Stratum 4	80.0	27	36	962.0	1.48	53	41.1	381
B-07	16.0	-4.9	Stratum 4	80.0	25	33	1,275.0	1.29	43	39.1	353
B-08	41.0	-29.5	Stratum 4	80.0	22	29	2,706.1	0.88	26	35.1	310
B-09	24.0	-11.0	Stratum 4	80.0	32	43	2,286.8	0.96	41	38.7	451
B-11	34.0	-20.4	Stratum 4	80.0	27	36	1,843.8	1.07	39	38.3	381
B-11	39.0	-25.4	Stratum 4	80.0	23	31	2,156.8	0.99	30	36.2	324
B-11	44.0	-30.4	Stratum 4	80.0	69	92	2,469.8	0.93	85	44.9	973
B-12	26.0	-15.0	Stratum 4	80.0	18	24	1,589.4	1.15	28	35.7	254
B-12	29.0	-18.0	Stratum 4	80.0	35	47	1,777.2	1.09	51	40.7	494
B-12	34.0	-23.0	Stratum 4	80.0	34	45	2,090.2	1.01	46	39.8	480
B-13	38.0	-27.1	Stratum 4	80.0	28	37	2,269.4	0.97	36	37.6	395
B-13	44.0	-33.1	Stratum 4	80.0	44	59	2,645.0	0.89	52	40.9	621
B-14	31.0	-21.0	Stratum 4	80.0	42	56	1,447.2	1.21	68	43.7	593
B-14	33.3	-23.3	Stratum 4	80.0	R	133	1,591.2	1.15	154	44.9	1,411
B-15	16.0	-6.5	Stratum 4	80.0	17	23	1,030.2	1.43	32	36.7	240
B-15	19.0	-9.5	Stratum 4	80.0	33	44	1,218.0	1.32	58	42.0	466
B-15	24.0	-14.5	Stratum 4	80.0	53	71	1,531.0	1.18	83	44.9	748
B-15	29.0	-19.5	Stratum 4	80.0	28	37	1,844.0	1.07	40	38.5	395
B-15	34.0	-24.5	Stratum 4	80.0	13	17	2,157.0	0.99	17		
B-15	39.0	-29.5	Stratum 4	80.0	23	31	2,470.0	0.93	28		
B-16-20	26.0	-16.0	Stratum 4	80.0	28	37	1,938.8	1.04	39	38.3	395
B-19-20	36.0	-25.0	Stratum 4	80.0	8	11	2,140.2	0.99	11	30.4	113
B-20-20	36.0	-25.0	Stratum 4	80.0	3	4	2,969.6	0.84	3	26.7	42
B-20-20	41.0	-30.0	Stratum 4	80.0	11	15	3,282.6	0.80	12	30.7	155
B-20-20	46.0	-35.0	Stratum 4	80.0	32	43	3,595.6	0.77	33	36.9	451

Summary of Standard Penetration Test Results: Stratum 4

Delaware Valley Works - Pre-Design Investigation

Boring ID	Test Depth (ft-bgs)	Test Elevation (ft-msl)	Soil Unit	Hammer Energy Transfer Ratio [1] (%)	N_m (blows/ft)	N_{60} (blows/ft)	Effective Vertical Stress, σ'_{vo} (psf)	C_N	$N_{1,60}$ (blows/ft)	Friction Angle, ϕ' [2] (degrees)	Elastic Modulus, Sands with Fines, E [3] (ksf)
B-20-20	51.0	-40.0	Stratum 4	80.0	67	89	3,908.6	0.74	66	43.4	945
B-22-20	31.0	-19.0	Stratum 4	80.0	4	5	2,169.8	0.99	5	27.7	56

Acronyms:

R = Refusal

WOH = Weight of Hammer

Mean Friction Angle (degrees): 38.2

Mean Elastic Modulus (ksf): 479

Notes:

(1) Hammer energy transfer ratio is assumed to be 80.0 percent for tests performed with automatic trip hammer.

(2) Correlation to friction angle from Peck et al. [1974], modified by Carter and Bentley [1991]. Correlation is only valid for coarse-grained soils.

(3) Correlation to elastic modulus from Kulhawy and Mayne [1990] for normally consolidated sands with fines.

Summary of Standard Penetration Test Results: Stratum 5

Delaware Valley Works - Pre-Design Investigation

Boring ID	Test Depth (ft-bgs)	Test Elevation (ft-msl)	Soil Unit	Hammer Energy Transfer Ratio [1] (%)	N_m (blows/ft)	N_{60} (blows/ft)	Effective Vertical Stress, σ'_{vo} (psf)	C_N	$N_{1,60}$ (blows/ft)	Friction Angle, ϕ' [2] (degrees)	Elastic Modulus, Sands with Fines, E [3] (ksf)
B-02	30.0	-20.5	Stratum 5	80.0	30	40	2,118.5	1.00	40	38.5	423
B-02	35.0	-25.5	Stratum 5	80.0	42	56	2,306.5	0.96	54	41.3	593
B-03	26.0	-15.5	Stratum 5	80.0	10	13	1,891.2	1.06	14	31.5	141
B-03	31.0	-20.5	Stratum 5	80.0	23	31	2,079.2	1.01	31	36.4	324
B-03	36.0	-25.5	Stratum 5	80.0	38	51	2,267.2	0.97	49	40.4	536
B-05	26.0	-15.0	Stratum 5	80.0	13	17	1,507.3	1.18	21		
B-05	31.0	-20.0	Stratum 5	80.0	13	17	1,695.3	1.12	19		
B-05	36.0	-25.0	Stratum 5	80.0	20	27	1,883.3	1.06	28		
B-05	41.0	-30.0	Stratum 5	80.0	49	65	2,071.3	1.01	66		
B-05	46.0	-35.0	Stratum 5	80.0	47	63	2,259.3	0.97	61		
B-05	51.0	-40.0	Stratum 5	80.0	26	35	2,447.3	0.93	32		
B-06	36.0	-25.4	Stratum 5	80.0	22	29	1,923.4	1.05	31		
B-07	21.0	-9.9	Stratum 5	80.0	12	16	1,538.0	1.17	19		
B-07	26.0	-14.9	Stratum 5	80.0	23	31	1,726.0	1.11	34		
B-07	31.0	-19.9	Stratum 5	80.0	19	25	1,914.0	1.05	27		
B-07	36.0	-24.9	Stratum 5	80.0	30	40	2,102.0	1.00	40		
B-08	46.0	-34.5	Stratum 5	80.0	15	20	3,019.1	0.84	17		
B-08	51.0	-39.5	Stratum 5	80.0	13	17	3,207.1	0.81	14		
B-08	56.0	-44.5	Stratum 5	80.0	35	47	3,395.1	0.79	37		
B-08	61.0	-49.5	Stratum 5	80.0	20	27	3,583.1	0.77	20		
B-09	29.0	-16.0	Stratum 5	80.0	9	12	2,537.3	0.91	11		
B-09	39.0	-26.0	Stratum 5	80.0	30	40	2,913.3	0.85	34		
B-09	44.0	-31.0	Stratum 5	80.0	42	56	3,101.3	0.83	46		
B-11	49.0	-35.4	Stratum 5	80.0	26	35	2,720.3	0.88	31	36.4	367
B-12	39.0	-28.0	Stratum 5	80.0	38	51	2,340.7	0.95	48		
B-12	44.0	-33.0	Stratum 5	80.0	38	51	2,528.7	0.91	46		
B-13	49.0	-38.1	Stratum 5	80.0	22	29	2,958.0	0.85	25		
B-13	54.0	-43.1	Stratum 5	80.0	34	45	3,146.0	0.82	37		
B-13	59.0	-48.1	Stratum 5	80.0	38	51	3,334.0	0.80	40		
B-14	39.0	-29.0	Stratum 5	80.0	24	32	1,885.5	1.06	34		
B-14	44.0	-34.0	Stratum 5	80.0	16	21	2,073.5	1.01	22		
B-15	44.0	-34.5	Stratum 5	80.0	49	65	2,783.0	0.87	57		
B-15	49.0	-39.5	Stratum 5	80.0	30	40	2,971.0	0.84	34		
B-15	54.0	-44.5	Stratum 5	80.0	47	63	3,159.0	0.82	51		
B-15	59.0	-49.5	Stratum 5	80.0	49	65	3,347.0	0.80	52		

Acronyms:

R = Refusal

WOH = Weight of Hammer

Mean Friction Angle (degrees): 37.4

Mean Elastic Modulus (ksf): 397

Notes:

(1) Hammer energy transfer ratio is assumed to be 80.0 percent for tests performed with automatic trip hammer.

(2) Correlation to friction angle from Peck et al. [1974], modified by Carter and Bentley [1991]. Correlation is only valid for coarse-grained soils.

(3) Correlation to elastic modulus from Kulhawy and Mayne [1990] for normally consolidated sands with fines.

Summary of Standard Penetration Test Results: Stratum 6

Delaware Valley Works - Pre-Design Investigation

Boring ID	Test Depth (ft-bgs)	Test Elevation (ft-msl)	Soil Unit	Hammer Energy Transfer Ratio [1] (%)	N_m (blows/ft)	N_{60} (blows/ft)	Effective Vertical Stress, σ'_{vo} (psf)	C_N	$N_{1,60}$ (blows/ft)	Friction Angle, ϕ' [2] (degrees)	Elastic Modulus, Sands with Fines, E [3] (ksf)
B-02	40.0	-30.5	Stratum 6	80.0	61	81	2,519.5	0.92	75		
B-02	44.9	-35.4	Stratum 6	80.0	R	133	2,826.2	0.87	115		
B-02	50.0	-40.5	Stratum 6	80.0	46	61	3,145.5	0.82	50		
B-03	41.0	-30.5	Stratum 6	80.0	66	88	2,517.7	0.92	81	44.9	931
B-03	46.0	-35.5	Stratum 6	80.0	63	84	2,830.7	0.86	73	44.5	889
B-06	41.0	-30.4	Stratum 6	80.0	52	69	2,173.9	0.99	68		
B-06	45.3	-34.7	Stratum 6	80.0	R	133	2,443.1	0.93	124		
B-07	40.4	-29.3	Stratum 6	80.0	R	133	2,314.9	0.96	127	44.9	1,411
B-09	49.0	-36.0	Stratum 6	80.0	60	80	3,351.8	0.79	64	43.1	846
B-12	49.0	-38.0	Stratum 6	80.0	61	81	2,779.2	0.87	71		
B-13	63.4	-52.5	Stratum 6	80.0	R	133	3,546.9	0.77	103	44.9	1,411
B-13	69.0	-58.1	Stratum 6	80.0	60	80	3,897.5	0.74	59	42.2	846
B-14	49.0	-39.0	Stratum 6	80.0	50	67	2,324.0	0.95	64	43.1	705

Acronyms:

R = Refusal

WOH = Weight of Hammer

Mean Friction Angle (degrees): 43.9

Mean Elastic Modulus (ksf): 1006

Notes:

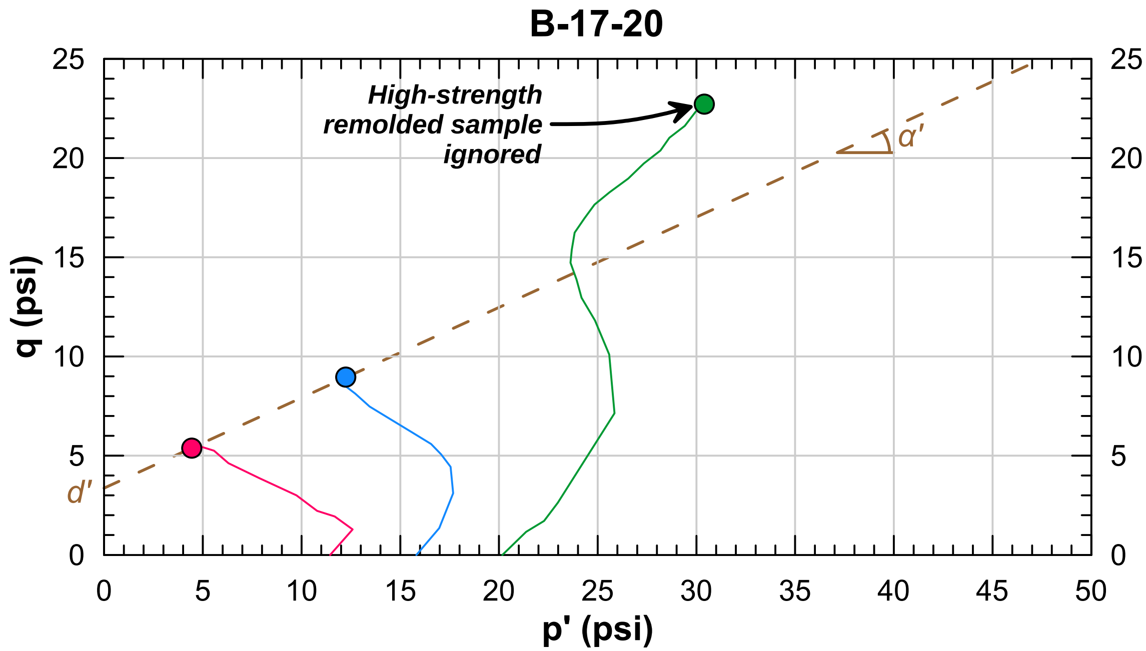
(1) Hammer energy transfer ratio is assumed to be 80.0 percent for tests performed with automatic trip hammer.

(2) Correlation to friction angle from Peck et al. [1974], modified by Carter and Bentley [1991]. Correlation is only valid for coarse-grained soils.

(3) Correlation to elastic modulus from Kulhawy and Mayne [1990] for normally consolidated sands with fines.

ATTACHMENT V
Shear Strength Properties

Drained Shear Strength
Stratum 2

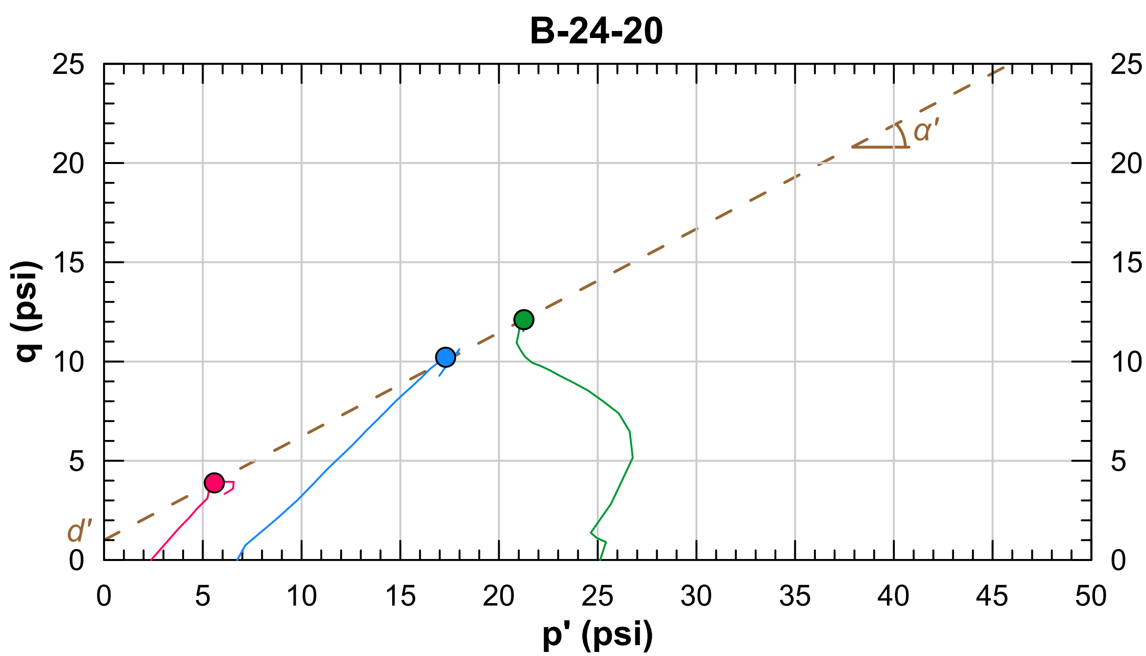


Stress Path Space

d' = 3.3 psi = 475.1 psf
α' = 25.1 degrees

Mohr-Coulomb Space

c' = 3.7 psi = 537.4 psf
ϕ' = 27.9 degrees

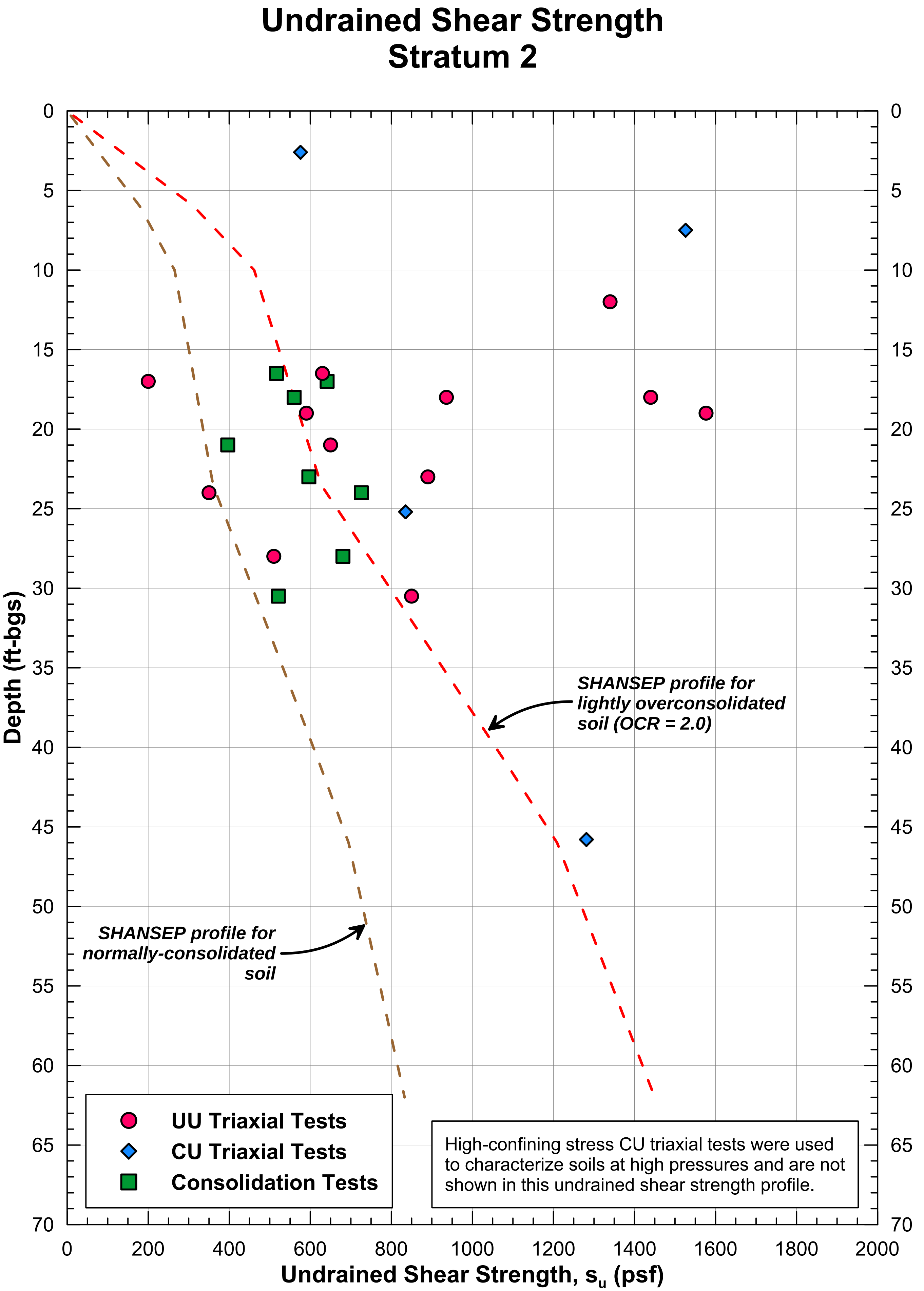


Stress Path Space

d' = 0.9 psi = 129.6 psf
α' = 27.7 degrees

Mohr-Coulomb Space

c' = 1.1 psi = 152.2 psf
ϕ' = 31.6 degrees



Undrained Shear Strength
Stratum 2
Depth (ft-bgs)
Undrained Shear Strength, s_u (psf)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
0
200
400
600
800
1000
1200
1400
1600
1800
2000
SHANSEP profile for lightly overconsolidated soil (OCR = 2.0)
SHANSEP profile for normally-consolidated soil
UU Triaxial Tests
CU Triaxial Tests
Consolidation Tests
High-confining stress CU triaxial tests were used to characterize soils at high pressures and are not shown in this undrained shear strength profile.

Summary of Unconsolidated Undrained Triaxial Compression Tests

Delaware Valley Works - Pre-Design Investigation

Boring ID	Sample Depth (ft-bgs)	Sample Elevation (ft-msl)	Soil Unit	Water Content, ω_o (%)	Total Unit Weight, γ_t (pcf)	Dry Unit Weight, γ_d (pcf)	In Situ Total Vertical Stress, σ_{vo} (psf)	In Situ Effective Vertical Stress, σ'_{vo} (psf)	Total Confining Stress, σ_c (psf)	Deviator Stress, $(\sigma_1 - \sigma_3)$ (psf)	Undrained Shear Strength, s_u (psf)	Axial Strain at Failure, ε_f (%)
B-06	18.0	-7.4	Stratum 2	161.9	73.2	27.9	1,970	1,103	864	1,872	936	7.6
B-09	18.0	-5.0	Stratum 3	22.9	129.0	105.0	2,306	1,901	800	2,880	1,440	12.6
B-11	12.0	+1.6	Stratum 2	21.7	130.7	107.4	1,449	1,075	800	2,680	1,340	15.0
B-11	21.0	-7.4	Stratum 2	117.5	83.3	38.3	2,286	1,350	800	1,300	650	12.1
B-11	30.5	-16.9	Stratum 2	132.3	76.3	32.8	3,170	1,641	1,200	1,700	850	8.1
B-12	17.0	-6.0	Stratum 2	114.9	86.9	40.4	2,062	1,282	800	400	200	11.9
B-12	24.0	-13.0	Stratum 2	84.8	90.1	48.8	2,713	1,496	1,000	700	350	15.0
B-13	16.5	-5.6	Stratum 2	78.8	93.2	52.1	2,016	1,548	800	1,260	630	10.4
B-13	28.0	-17.1	Stratum 2	77.8	94.2	53.0	3,085	1,899	1,200	1,020	510	15.0
B-14	23.0	-13.0	Stratum 2	225.3	73.0	22.4	2,324	1,138	800	1,780	890	6.9
B-19-20	19.0	-8.0	Stratum 2	62.9	111.4	68.4	2,337	1,588	2,880	1,181	590	6.8
B-21-20	19.0	-10.0	Stratum 2	45.9	90.0	61.7	2,329	1,643	2,880	3,154	1,577	11.3

Notes:

(1) Testing performed in accordance with ASTM D2850.

Summary of Consolidated Undrained Triaxial Compression Tests

Delaware Valley Works - Pre-Design Investigation

Boring ID	Sample Depth (ft-bgs)	Sample Elevation (ft-msl)	Soil Unit	Water Content, ω_o (%)	Total Unit Weight, γ_t (pcf)	Dry Unit Weight, γ_d (pcf)	In Situ Effective Vertical Stress, σ'_{vo} (psf)	Effective Confining Stress, σ'_c (psf)	Maximum Principal Stress Ratio, (σ'_1 / σ'_3)					Maximum Deviator Stress, $(\sigma_1 - \sigma_3)$		
									Maximum Principal Stress Ratio, (σ'_1 / σ'_3)	Principal Stress, p' (psi)	Principal Stress, q (psi)	Effective Friction Angle, ϕ' (deg)	Effective Cohesion, c' (psf)	Maximum Deviator Stress, $(\sigma_1 - \sigma_3)$ (psf)	Undrained Shear Strength, s_u (psf)	Axial Strain at Failure, ε_f (%)
B-17-20	21.5	-12.5	Stratum 2	56.0	104.9	67.2	1,536	1,648	-10.5	4.4	5.4			1,670	835	9.7
B-17-20	21.5	-12.5	Stratum 2	53.8	104.9	68.2	1,536	2,277	6.8	11.9	8.9	27.9	537	2,563	1,282	10.3
B-17-20	21.5	-12.5	Stratum 2	36.6	88.6	64.9	1,536	2,905	6.9	30.4	22.7			6,538	3,269	13.2
B-24-20	14.0	0.0	Stratum 2	24.3	118.6	95.4	1,246	342	5.6	5.6	3.9			1,152	576	15.5
B-24-20	14.0	0.0	Stratum 2	22.0	137.3	112.5	1,246	971	3.9	18.0	10.6	31.6	152	3,053	1,526	8.5
B-24-20	14.0	0.0	Stratum 2	19.8	103.4	86.3	1,246	3,618	3.6	21.3	12.1			3,485	1,742	15.5

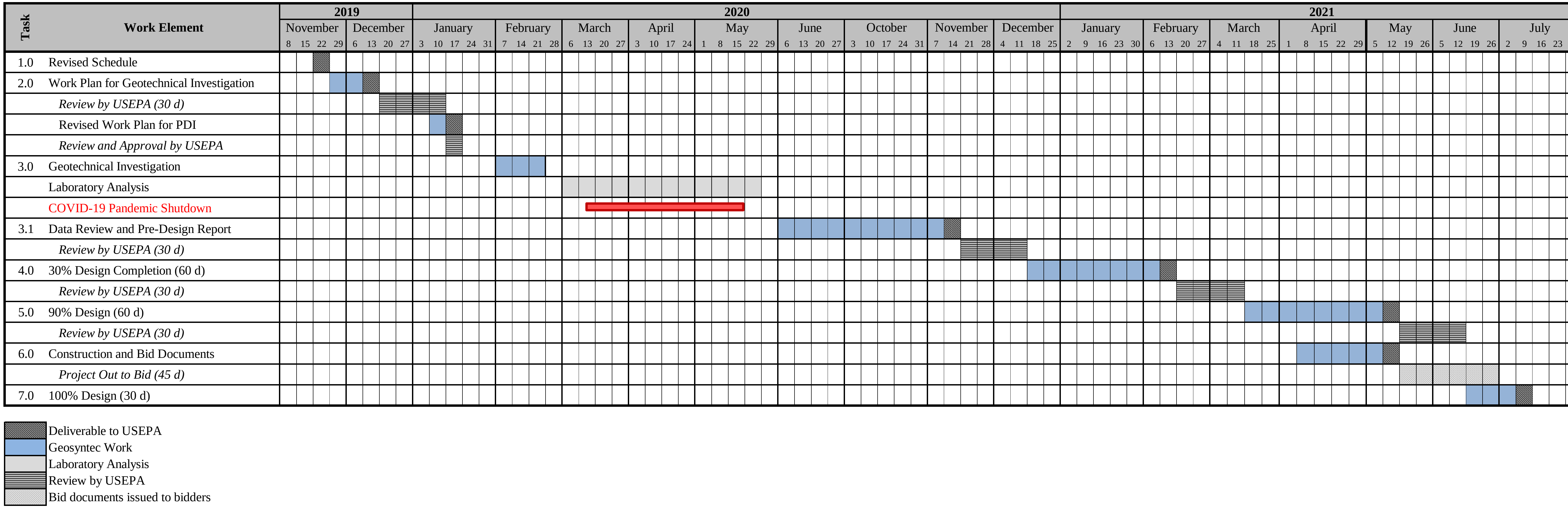
Notes:

(1) Testing performed in accordance with ASTM D2850.

APPENDIX D

PROJECT SCHEDULE
(UPDATED)

PROJECT SCHEDULE (REVISED NOVEMBER 2020)
DELAWARE VALLEY WORKS SOUTH PARCEL, PHASE 2
Claymont, Delaware



Notes:

The schedule represents the best case alternative.

Meetings and internal review with D2 are not shown but are a part of each Task.

1.0 The revised schedule is this deliverable. Schedule will be updated as needed

2.0 Geosyntec will prepare a work plan for the geotechnical investigation required to collect data that will be used to direct cap design. Task will also include review of existing documentation. The work plan will include the approximate location and number of borings, targeted depths, and sampling and analysis plan. Work plan will also include health and safety procedures, QA/QC, and procedures for decontamination.

3.0 The geotechnical investigation will consist of mobilizing to site site, deploying a drill rig that is equipped to drill to targeted depths, pushing Shelby tubes. Soil testing to include grain size analysis, bulk density, Atterberg limits, permeability, and tests for consolidation parameters that can be used to confirm hydraulic conductivity of the soil and for future land redevelopment.

3.1 Data review consists of the receipt and analysis of data from laboratories and analysis for future potential site development as it applies to options for cap design. Pre-design report will summarize field investigation and lay the foundation for the 30% design.

4.0 Geosyntec will prepare a 30% preliminary design in accordance with the Statement of Basis. It will include grading plans, cap cross-sections, conceptual stormwater management, as well as major details regarding the interaction of the cap with subsurface utilities, the shoreline and/or bulkheads, and the Phase 1 cap. The 30% design will also include an updated Materials Management Plan and Cap Management Plan to incorporate differences in the design of the Phase 2 cap. Technical specifications from the Phase 1 will also be updated. Relevant design calculations will be included.

5.0 The 90% design will incorporate USEPA comments on the 30% design and include the details needed for construction. It will also include sequencing of construction at sufficient detail to meet regulatory requirements.

6.0 Construction and bid documents will be created and submitted for tender using the 90% design.

7.0 The 100% design will incorporate USEPA comments on the 90% design and be sealed by the certifying engineer.